FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Analysis and Improvement of Returnable Assets Control Processes

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ELECTROTECNIC AND COMPUTER ENGINEERING MASTER'S THESIS

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29th July of 2015

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Bruno Bastos Martins

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To my grandparents.

Abstract

Returnable assets control is an extremely relevant and important activity for all companies that use them, within their reverse logistics scope.

This is also an economic and scientific challenge with an abundant literature about optimization methods for supply chain planning involving the return of products close to their expiration date, with quality issues or containing reusable components.

This thesis' goal is to analyse all processes related to monitoring, tracking, controlling and returning refillables of any kind, within the ones used at Unicer Bebidas, S.A., and propose improvements to them.

These assets are highly valuable to the company's activity, thus, their correct retrieval is of the utmost importance. Failing to correctly return them have significant impacts on the production centres' filling lines, causing efficiency losses and even threats to the operators safety. Furthermore, it also provokes the incorrect return of deposit fees associated to the returnable assets, and the need to replace them with new ones.

To assess where the refillables are used and how they are controlled and retrieved, several meetings with the different departments were carried out and their processes followed. This analysis resulted on the identification of several problems regarding the bottles' utilisation and return, evaluated in a total loss of over 1 000 000€.

Some improvements were proposed, their benefits and disadvantages measured, and a selected amount of them were included on a business case in order to be implemented according to the company's strategy. The most significant one is an automatic or manual verification of the missing and undue bottles inside the returned crates, upon the arrival of the retrieval trucks. With this, Unicer can save up to 1 000 000€ per year with an investment of less than 600 000€.

This study's results are considered a good practice to have within the beverages industry, and may even be considered to be implemented on other Unicer's and Carlsberg's production centres around the world.

Resumo

O controlo do vasilhame é uma atividade extremamente relevante e importante para todas as empresas que os usam, no âmbito das atividades de logística inversa.

Isto representa um desafio, não só económico mas também científico, sendo abundante a literatura sobre métodos de otimização para o planeamento de cadeias de abastecimento com a recolha dos bens em fim de validade, problemas de qualidade ou componentes reutilizáveis.

O objetivo desta dissertação é a análise de todos os processos associados à monitorização, rastreabilidade, controlo e recolha de vasilhame dos que são utilizados na Unicer Bebidas, S.A., e propôr as respetivas melhorias.

Os vasilhames sao muito valiosos na actividade da empresa, por isso o seu retorno é bastante importante. Falhar na sua correcta devolução tem impactos significativos para as linhas de produção, causando perdas de eficiência e, ainda, ameaça a segurança dos operadores. Adicionalmente, também provoca a devolução incorreta das cauções associadas ao retorno do vasilhame, e a necessidade os substituir por novos.

Para avaliar onde o vasilhame é utilizado, controlado e recuperado, foram realizadas várias reuniões com os diferentes departamentos, e os seus processos foram acompanhados. Esta análise resultou na identificação de vários problemas na utilização e retorno de garrafas, avaliados num total de 1 000 000€.

Várias melhorias foram propostas, os seus benefícios e desvantagens medidos, e uma selecao delas foram incluídas no caso de estudo para serem implementadas de acordo com a estratégia da empresa. A mais relevante é uma verificação automática ou manual das garrafas indevidas ou em falta à chegada dos camiões de retorno de garrafa. Com isto, a Unicer pode poupar até 1 000 000€ por ano com um investimento inferior a 600 000€.

Os resultados deste estudo são considerados como boas práticas a seguir dentro da industria das bebidas, e podem até ser implementadas noutros centros de produção da Unicer e da Cralsberg no mundo.

Acknowledgments

First of all, I want to thank my parents for raising me the way they did and for always supporting me during all these years.

I also thank my sister for all the great moments we shared, and will continue to share, all our lives.

Likewise, I thank my girlfriend for the support she gave me during my degree's hard times, for encouraging me to never give up and for always believing in our love.

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For the constant support and sympathy, for sharing their knowledge and experience, and for inspiring me to exceed my own expectations, I thank professors José Fernando Oliveira and Maria Antónia Carravilla.

In last, but not least, I want to thank Unicer's executive board for providing me the opportunity to get to know how a real industry works, and I also want to thank all Unicer's personnel that assisted me through this study, specially Pedro Nuno Oliveira and Miguel Sousa who shared my difficulties and achievements.

Bruno Bastos Martins

"The first step toward change is awareness.
The second step is acceptance."

Nathaniel Branden

Contents

List of Figures

List of Tables

Abbreviations

APs	Access Points
GPS	Global Positioning System
HMC	Hidden Markov Chains
H&S	Health and Safety
kL	Kilolitre
LOS	Line-Of-Sight
MES	Manufacturing Execution System
MPs	Monitoring Points
NLOS	Non-Line-Of-Sight
NRGB	Non-Returnable Glass Bottles
OAE	Overall Asset Effectiveness
OEE	Overall Equipment Effectiveness
OFE	Overall Factory Effectiveness
OTE	Overall Throughput Effectiveness
PDA	Portable Digital Assistant
PEE	Production Equipment Effectiveness
RF	Radio-Frequency
RFID	Radio-Frequency Identification
RGB	Returnable Glass Bottles
ROI	Region Of Interest
ROI	Return Of Investment
RSS	Received Signal Strength
SKU	Stock Keeping Unit
TEEP	Total Equipment Effectiveness Performance
UHF	Ultra High Frequency
WLAN	Wireless Local Area Network

Chapter 1

Introduction

This document has been produced as an Electrical and Computers Engineering Master's thesis at Faculdade de Engenharia da Universidade do Porto.

This master's thesis was developed in a business context at the Leça do Balio facility of Unicer Bebidas, S.A. in Porto, Portugal with the goal of studying the problems inherent to the returnable assets used in their business, and suggest some improvements to fight them. At an early stage of this project several data collection meetings and analysis were undertaken to identify the problems Unicer is facing with their returnable assets. Afterwards, the investigation and serialisation of improvements and solutions to the identified problems were carried out, and concluded with the implementation and recommendation of some.

An introductory presentation to the executive board was also made, in order to increase the awareness of the problems Unicer is facing, their impacts and causes, as well as to provide an insight on some measures to minimise them.

This study's most relevant result was the preparation of a business case, that, at the time this thesis was written, is scheduled to be presented to Unicer's executive board on the 19th July of 2015, with solutions that allow Unicer to save over one million euros per year, regarding the retrieval of their returnable assets.

1.1 Returnable Assets

On the business context, assets are valuable items whose ownership is convertible into cash. They are a company's possessions as, for example, its inventory, equipments and properties. The returnable assets, are the ones whose ownership is transferred to the company's clients with the purpose of transporting its products or improving their conditions and visibility. In the food and beverages industry, these assets are known as vessels, empties or refillables.

Vessels are hollow containers especially used to hold liquids and the word's origin is the Latin word vascellum. Nowadays they have a wide variety of applications, formats and sizes, such as bottles to contain water, juices and other drinks in small amounts, kegs to move larger quantities of drinkable liquids, oil and gases and even cistern vehicles with enormous capacities to transport all varieties of liquids and gases all around the world. In the beverages industry, there are a few more types of returnable assets that need to be taken into consideration which aid the handling of the other vessels and allow them to be transported in batches, like the beer crates and the wooden or plastic pallets. Due to these containers' different applications and characteristics, some of them are considered valuable and, for that reason, most companies implement different processes to have them safely and timely returned.

1.2 Unicer Bebidas, S.A.

Figure 1.1: Unicer's logo.

Unicer (current logo in Figure 1.1) has one hundred and twenty five years of history having started its activity on 7th March of 1890 as the result of merging seven breweries into Companhia União Fabril Portuense das Fábricas de Cerveja e Bebidas Refrigerantes with the acronym CUFP. This limited company started with only thirteen workers and a capital of seven thousand "réis" which was the currency used at the time and its monetary value alone is equivalent to less than four euro cents at the present time. CUFP has strived against its competitors, the environmental changes, both World Wars, the carnation revolution and many other events and adversities until it was transformed into the public company known as Unicer – União Cervejeira E. P. by merging three breweries and one soft drinks factory on 30th December of 1977. After eleven years, on July 1988, the cabinet council announces that Unicer will be the first public company to be privatized, undergoing another transformation, this time into being a limited company of public capital.

Unicer's strategy and product catalogue were expanded throughout the 20th century by manufacturing not only beer but also soda drinks and iced teas and selling them throughout the other continents. Already in the 21st century, on 2001, it became Unicer – Bebidas de Portugal, S. A. with the goal of affirming itself as a beverage company instead of being just a brewery. It didn't wasted any time and in the following year (2002) it acquired the bottled water group Vidago, Melgaço and Pedras Salgadas (VMPS) along with the coffee company A Caféeira to meet its objectives.

Presently, Unicer's vision is to become the number one choice wherever Unicer and its brands are, and its mission is to assure the remuneration and trust of its shareholders, to be the preferred partner of its clients and the consumers' number one choice. In order to fulfil this vision Unicer focus on the quality of its products and the value of its brands being an ISO 9001, ISO 14001, ISO 22000 and OSHAS 18001 certified company and having a vast marketed brand portfolio mainly formed by the beer brands Super Bock, Cristal, Carlsberg and Cheers, the bottled water brands Pedras, Vitalis and Vidago, the soft drinks brands Frutis, Snappy, Frisumo, Guaraná and Frutea, the wine brands Vini, Quinta do Minho, Vinha das Garças and Monte Sacro, and the cider brand Somersby. Unicer is currently held in 56% by the portuguese group Viacer constituted by the Violas, Arsopi and BPI groups and in 44% by Carlsberg in Denmark.

The internationalisation of Unicer's brands is part of its strategy to stimulate the company's competitiveness and sustainability, with the European and Angolan markets being the most significant ones outside Portugal. Angola continues to be Unicer's main external market representing 60% of its beer exportation volume. The focus of its international business is the development and implementation of structuring projects all around the world, including the United Kingdom, Mozambique, Brazil and the United States of America.

1.3 Returnable Assets and Unicer Bebidas, S.A.

At Unicer's facilities the high variety of returnable assets used are made from diverse materials and with different capacities. They can be aggregated in bottles, kegs, CO_2 pipes, bottle crates and pallets, and require a deposit fee from its clients according to their characteristics and their ability to be reused.

The containers that don't require a deposit fee aren't returned to Unicer's facilities, and their cost is reflected on the final product, thus, being charged to the customers. These containers' thickness is small when compared to the refillables', and their shape is, on most cases, also slightly different so that they are easily identified anywhere by anyone and in the filling lines by the sorting machines.

On the other side, the returnable vessels are sturdy enough to withstand several cycles on the production lines and the market, being transported in conveyor belts, forklifts, trucks, cars and even by hand. Also, their shape is mostly conical to better suit the washing and drying processes. Generally, they're more expensive due to their thickness and their specific materials, thus representing a valuable asset for any beverage company. This containers have distinct deposit fees according to their characteristics (size, thickness, cost, etc.) and are identified through the stock keeping unit (SKU), which is an unique internal code. A complete list of all returnable assets, their deposit fees and capacities can be seen on Appendix A.

Given the value of the returnable assets, it is of the utmost importance that these are returned in good conditions and in its entirety so that the logistics and production departments can plan their operations efficiently.

If these assets aren't returned correctly they arise several issues on the production lines from their high breakage and mixing rates, posing a threat to the operators, jamming the equipments that handle them and, thus, lowering the overall equipment effectiveness (OEE). Additionally, the missing and the incorrectly returned assets require further investments to replace them with new vessels, increasing the company's expenses and lowering its profits. Ultimately, the deposit fees returned to retrieve these faulty and absent assets provoke unpredictable fluctuations on their deposit fees' bank account.

Therefore, the main returnable assets related problems are:

- Traceability and Identification;
- Control and Fragility;
- Verification and Management.

1.4 Motivation

Getting to know how a real company, with Unicer's dimension and complexity, works represented an enormous challenge and was a great motivational factor for the development of this study.

During it, was possible to follow the whole journey made by Unicer's products and assets, starting on the production plant, going to the market and coming back to the factory for another cycle. There was also the opportunity to explore the same tools and processes used by Unicer's technicians to analyse the company's activities and the assets' flow. Additionally, seeing an actual factory working 24 hours per day, 7 days per week also provided an extra motivation to enhance Unicer's processes and help it achieve an even higher level.

1.5 Thesis Structure

On chapter 2 is described and explained the returnable assets' importance for Unicer, an introduction to the most common issues of handling them, some of the related work that was useful for this thesis development, along with a benchmark of the good practices performed by Carlsberg and Luís Simões.

Chapter 3 explains the Unicer's supply chain to contextualise the returnable assets study and provide an insight of the different activities involving the returnable assets.

On chapter 4 the vessels' control processes performed at Unicer since they enter the filling line until they're returned back to the production centre are detailed.

Chapter 5 describes the most pertinent problems, their causes assessed and their impacts calculated.

On chapter 6 the improvements proposals are specified, indicating their benefits and disadvantages, their impact on Unicer's processes and systems, and what's their implementation state at the time this thesis was written.

Finally, chapter 7 concludes this document with a review of the achieved results and some future work as well.

Chapter 2

State of the Art

In this chapter are presented the related work that was useful in analysing Unicer's processes and in studying possible solutions. A set of the best practices on handling returnable assets in Europe is also described to understand how the other breweries control and manage them.

2.1 Traceability and Identification

The traceability and identification of returnable assets provides their owner with the information to know where they are and, specifically, which ones are they.

There are several technologies used for wireless identification and localisation of objects and all of them have different specifications and applications. These technologies' most important characteristics, that need to be taken into consideration when selecting one above the other, are: range, cost and energy consumption.

2.1.1 Range

The range is affected by several variables, such as the communication technology itself, the absence of a line-of-sight (LOS) between the object to be detected and the reader (Choi et al. (2012)), the presence of metal objects in the devices' vicinity (Penttilä et al. (2006)), and even the temperature (Bannister et al. (2008)) and humidity of the air (Thelen (2004)).

The implementation of an active radio-frequency identification (RFID) system in a container terminal in South Korea is described by Choi et al. (2012) proposing a conjugation of the detected RFID distance with the pre-mapped pathways' information to estimate the position of moving cranes and yard tractors on a non-line-of-sight (NLOS) environment, pictured on Figure 2.1.

This method compares the distance information obtained from up to three radio-frequency (RF) readers with possible candidate positions. It also takes into consideration the largest angle of the triangle made by these readers, since the error between the estimated location and the actual one is significant if that angle is above a determined threshold, as illustrated on Figure 2.2.

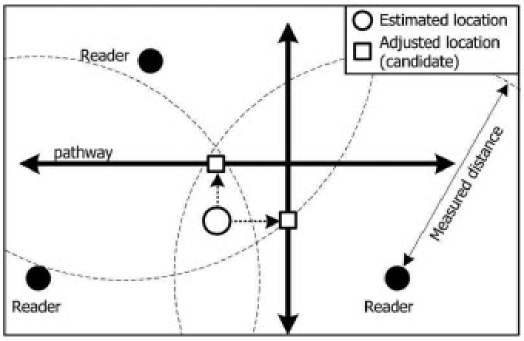


Figure 2.1: Error correction with pathway information example (in Choi et al. (2012))

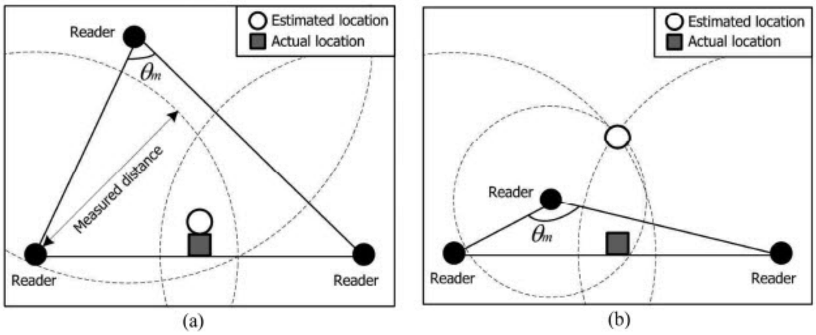


Figure 2.2: Variance of the location accuracy based on the size of θ_m (in Choi et al. (2012))

The achieved results with this system in NLOS conditions were impressive even in positions with only one RF reader or a high amount of obstacles and, as expected, were even better in branches were the NLOS conditions approach the existence of a LOS.

The effects of having metallic objects in the vicinity of an antenna are detailed by Penttilä et al. (2006) and consist in acting like a reflector of the signal wave. The reflected wave is out of phase with the original one by 180° thus, the sum of them results in a wave with amplitude between zero and double of the original, according to the signal's wave-length (λ) and the distance of the antenna to the metal reflector. If this distance is $n \cdot \lambda/2$ the result will be an amplification of the original signal and if it is $n \cdot \lambda/4$, excluding all distances equal to $n \cdot \lambda/2$, the reflector will provoke a zero sum wave. Figure 2.3 illustrates this phenomenon.

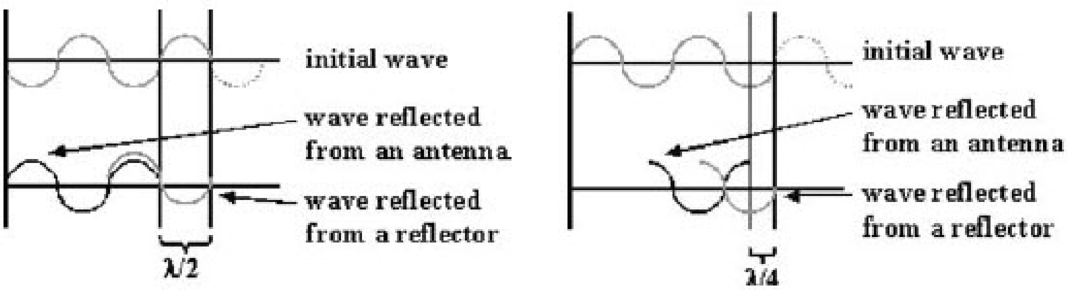


Figure 2.3: Signal wave reflection principle with different distances between an antenna and a reflector. Left: distance of $\lambda/2$. Right: distance of $\lambda/4$. (in Penttilä et al. (2006))

Throughout the simulation of an industrial environment, this study concluded, among other outcomes, that the presence of metal objects in the vicinity of RFID tags weakens the communication link.

The effects of temperature on the signal strength and nodes localisation were studied by Bannister et al. (2008). The temperature range analysed was between 25 °C and 65 °C and the received signal strength (RSS) was measured as a mean to locate the position of other devices within the network.

The graphics on Figure 2.4 show the decrease of the nodes connectivity and the increase of the ranging error as the temperature rises.

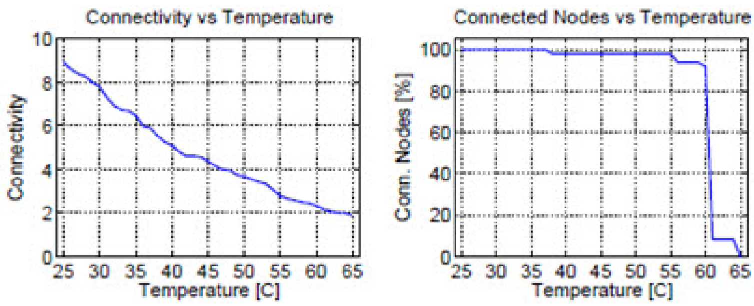


Figure 2.4: Evolution of the nodes' connectivity and the ranging error (in Bannister et al. (2008))

The environmental conditions are significant and directly affect the performance of radio transceiver devices. So, it is important to understand their impact on the performance of wireless sensor networks. Thelen (2004) studied the radio wave propagation within potato fields, as part of a project investigating the application of wireless sensor networks.

One of the measured variables was the air humidity and it was concluded that at night and during rain the radio waves propagate better than in times of the day with lower humidity, as it can be seen on Figure 2.5.

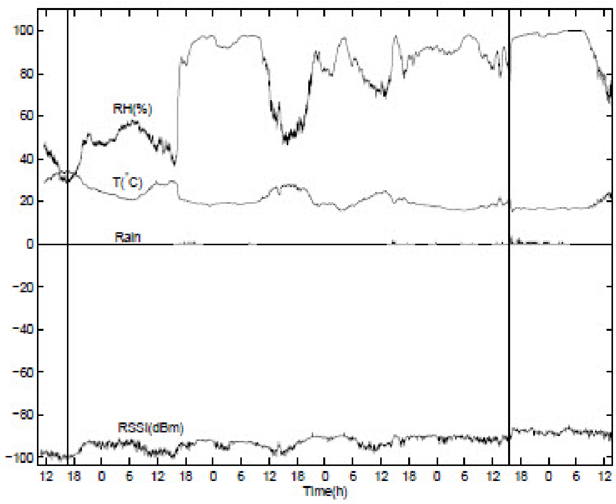


Figure 2.5: Evolution of the measured RSS, rain, temperature and relative humidity (in Thelen (2004))

2.1.2 Cost

The cost originates from three related sources: the implementation or setup expenses, the devices' prices and their consumed energy (Akyildiz et al. (2002); Mhatre e Rosenberg (2004)).

There are technologies such as the global positioning system (GPS) that have a lower setup cost when compared to a RF network but have a higher device price (N. Bulusu, J. Heidemann e Estrin (2000); Gaukler e Seifert (2007)). When selecting which technology to implement, a company has to analyse which one fits better with its own operational strategy, the technologies already applied on its partners and clients, the purpose and extent of the asset tracking system and weight the cost-benefit of each one of them accordingly.

2.1.3 Energy Consumption

As for the energy consumption of each solution there are two main factors to consider. The first one is if the devices will be active or passive and the second one is whether the devices will be connected to the power grid or will run on a battery of their own.

The main difference between an active and a passive solution is the periodicity by which the device informs where it is and in some cases the medium by which the communication is done, where an active solution is capable of transmitting frequently and a passive one requires to be near a detection equipment so that it may be identified and localised.

If the company prefers a solution that doesn't require the charge of any device, a passive solution or an active solution connected to a power source, like the power grid or a vehicle battery, are the best options. However, choosing an active solution based on a battery may prove to be effective despite requiring the charge of batteries from time to time when the vessels return to the factory which may even be done cordlessly with the current technologies available on the market.

A device-based system requires the existence of an equipment capable of actively communicating with another system be it a satellite, a cell tower or a modem to determine its position. On the other hand, a device-free system doesn't resort to any communication mechanism being passively detected and whose position is estimated according to previously recorded or already known information.

Eleryan (2011) presents an automatic localisation method based on the generation of a radio map and analysing the strength of a wireless local area network (WLAN) on both types of approaches, named AROMA. In this case, the device-based system requires the existence of a WLAN enabled device, such as a smartphone or a laptop, to identify its position through access points (APs). The device-free system estimates the position of the tracked object by analysing its effect on the signal strength. To do that, it requires both the APs and some monitoring points (MPs) which are other WLAN enabled devices with fixed positions. In both cases the system has to go through two different phases, a first one to map the radio signal along the area of interest and a second one to determine the localisation of the tracked object. In the device-based system the radio map is built using the APs and a tracked device to record the signal strength at each possible position while on the device-free system the radio map is recorded resorting to the APs and the

MPs while a person moves throughout the object's possible positions without any WLAN enabled device, as illustrated on Figure 2.6.

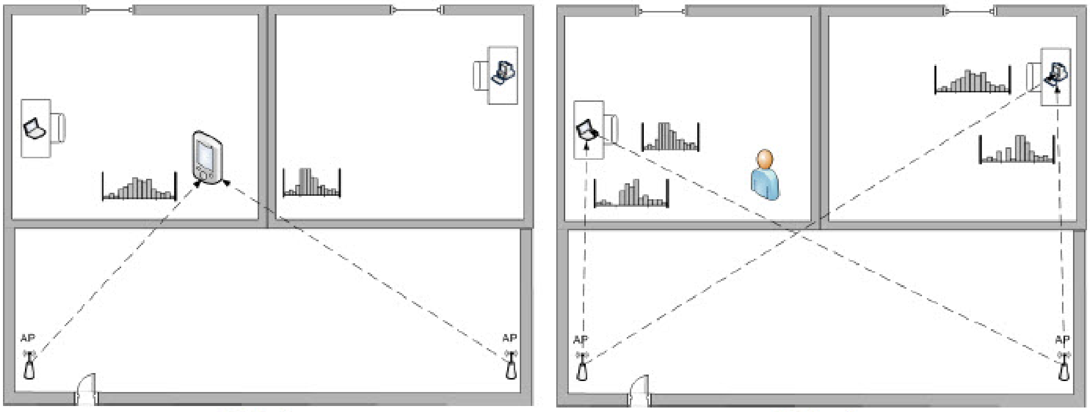


Figure 2.6: Illustration of the different methods to build the radio maps (in Eleryan (2011))

The proposed AROMA system models the RF propagation and the human shadowing effects by combining ray tracing techniques with the theory of waves diffraction achieving a maximum localisation error of 2.44 meters.

2.2 Control and Fragility

The reasons and motivations to control the vessels and their fragility are numerous. Starting on reducing the need to invest in containers (Fleischmann (2001)) and finishing on mitigating the human foot-print on Earth's environment (Kroon e Vrijens (1995)), companies have long adopted the use of reusable assets. Therefore, these need to be returned, controlled and maintained.

2.2.1 Reverse Logistics

After a careful analysis of previously published definitions and three of its main aspects, Fleischmann (2001) characterises Reverse Logistics as follows:

> "Reverse Logistics is the process of planning, implementing, and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain direction for the purpose of recovering value or proper disposal."

Hence, a reverse logistic system requires the transport of the empty vessels from its recipient back to the sender. Kroon e Vrijens (1995) describe three distinct systems models:

- Switch pool systems;
- Systems with return logistics;
- Systems without return logistics.

In *switch pool systems*, every participant is responsible for the activities inherent to reverse logistics, such as controlling and storing the vessels, and so, each one of them has an allotment of containers (Kroon e Vrijens (1995)) which is transferred between them as needed.

Kärkkäinen et al. (2004) describes *systems with return logistics* as those where the vessels are owned by a central agency which is responsible for returning them after they've been emptied. On these type of systems, the recipient stores the empty containers until there is a sufficient number of them so that it is cost-effective to collect them. They can be differentiated into transfer and depot systems.

The same vessels are always used by the sender in *transfer systems* and the control and maintenance are the responsibility of the sender as well.

Depot systems transfer the vessel related processes' responsibility to a central agency that stores, maintains and provides the senders with them, as needed. These systems can also be classified into two variants, the book and the deposit approaches.

In a *book system*, both the senders and the recipients are associated with accounts that are credited or debited according to package movements. Here, the central agency monitors the number of packages transported between the participants and the movements data from them.

In a *deposit system*, all parties pay a deposit fee for the vessels as they pass through it. A central agency is responsible for collecting the containers after they have been emptied and doesn't have the need to monitor them, since the deposit fee finances any loss or theft that may occur.

Karimi et al. (2005) refers that *systems without return logistics* are those where the sender is responsible of controlling, maintaining and storing the vessels that are rented from a central agency. In the event that the senders don't need the vessels anymore, they return them to the central agency.

Table 2.1 summarizes the differences between these different variations of return logistics.

Table 2.1: Process responsibility per reverse logistic types

	Ownership	Return	Storage	Mainte - nance	Control	Deposit	Monitoring
Switch Pool Systems	Each participant	-	Each participant	Each participant	Each participant	-	Each participant
Systems With Return Logistics:							
Transfer Systems	Central agency	Central agency	Sender	Sender	Sender	-	Sender
Depot Systems with Bookkeeping	Central agency	Central agency	Central agency	Central agency	Central agency	-	Account
Depot Systems with Deposit Fee	Central agency	Central agency	Central agency	Central agency	Central agency	Deposit Fee	Not necessary
Systems Without Return Logistics:							
Rental Systems	Central agency	Sender	Sender	Sender	Sender	Rent	Not available

2.2.2 Overall Equipment Effectiveness

As stated by Muchiri e Pintelon (2008) the OEE is a quantitative tool to measure a manufacturing process's productivity. Over the years, it was modified into several variants according to its concept of application, such as overall factory effectiveness (OFE), overall throughput effectiveness (OTE), production equipment effectiveness (PEE), overall asset effectiveness (OAE) and total equipment effectiveness performance (TEEP). However, its core use always remained the same, which is to measure the degree at which an equipment is working as it should. For that purpose, the OEE is meant to identify losses that reduce the equipments' effectiveness.

These losses can either be sporadic or chronic. The first ones are obvious and cause large deviations from the equipment's normal behaviour. The later are small and hidden disturbances resulting from multiple and simultaneous causes. Jeong e Phillips (2001) and Muchiri e Pintelon (2008) categorise and enumerate these losses as:

- Downtime losses:
  1. Equipment failure;
  2. Setup and adjustment;
- Speed losses:
  3. Idling and minor stoppages;
  4. Reduced speed;
- Quality losses:
  5. Defects in process;
  6. Reduced yield.

This resulted on calculating the OEE as a function of availability (A), performance (P) and quality (Q), as show on equation 2.1.

$$OEE = A * P * Q \tag{2.1}$$

With OEE's parameters being calculated according to equations 2.2, 2.4 and 2.5.

$$Availability\ (A) = \frac{Operating\ Time\ (h)}{Available\ Time\ (h)} * 100 \tag{2.2}$$

$$Operating\ Time = Available\ Time - Downtime \tag{2.3}$$

$$Performance\ (P) = \frac{Theoretical\ Cycle\ Time\ (h) * Actual\ Output(units)}{Operating\ Time\ (h)} \tag{2.4}$$

$$Quality\ (Q) = \frac{Total\ Production\ (units) - Defect\ Amount\ (units)}{Total\ Production\ (units)} * 100 \tag{2.5}$$

Thus, it is possible to assess a production line's equipments effectiveness by measuring these metrics and calculating the OEE value.

2.2.3 Quality Control

After being retrieved, the returnable assets need to be stored and, when necessary, they must be cleaned and maintained in order to assure that the hygiene and safety measures are respected as well as the satisfiability of the consumers. Besides these concerns, the quality of the final product requires that the correct vessel is used and its condition is good.

Campos et al. (2010) developed a computer vision system capable of detecting if the correct crate is being processed and undamaged, whether it is full or not, if there are bottles without caps, and whether they have the correct ones or not.

This system is constituted by two high frequency fluorescent lights and one charged-coupled device (CCD) camera packed inside a box and positioned above the beer crate. The captured photographs are analysed as demonstrated in 2.7 and if an error is detected that crate is identified and automatically separated from the others through another conveyor belt.

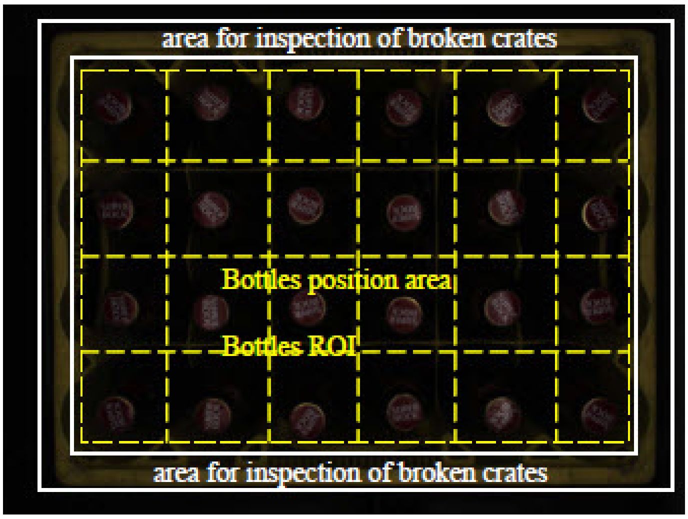


Figure 2.7: Photograph segmentation into area for inspection of broken crates, bottles position area and their region of interest (ROI) (in Campos et al. (2010))

The overall false rejection error percentage achieved with this system in the industrial environment is on the order of 0.74 % after having processed 26000 images of beer crates.

With the purpose of recognizing bottles inside their crates, a study of some applications of hidden Markov chains (HMC) was made by Aas et al. (1999) where a laser scan was used to extract the range and the intensity of crates containing bottles. Each different bottle type was modelled as a HMC model with five states and the scan-lines going through the middle of the bottle were extracted. Both can be seen in Figure 2.8.

The challenge of this part of the study was to match the unknown bottles with the bottle type it corresponds better.

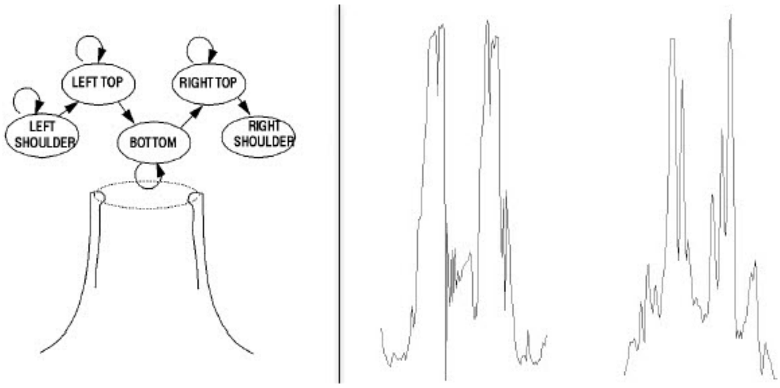


Figure 2.8: Left: HMC model of a bottle. Right: Scan-lines of range and intensity through the middle of the bottle (in Aas et al. (1999))

These two technologies represent valuables steps in the automation of the control processes upon arrival of vessels at beverages facilities. The one presented by Campos et al. (2010) is capable of filtering the incomplete crates that often are delivered in this kind of industries. Likewise, the application of HMC studied in Aas et al. (1999) is relevant in identifying and guaranteeing that the received bottles are the correct ones and are undamaged on the top-faced visible surfaces.

2.3 Good Practices Benchmark

In this study, several contacts with Carlsberg UK were made to establish a cooperation relationship to share the best practices performed on Carlsberg's factories all around the world. This involved the participation of Carlsberg's personnel to identify their markets' problems with returnable assets and the investigation of which measures to apply to fight them. The results of this study will be reported back to Carlsberg as the good practices performed in Portugal.

Furthermore, Unicer's transport operator partner, Luís Simões, was also contacted to assess a measure they have implemented with Spain's local breweries to minimise the costs and effects of having mixed and undue bottles returned to the production centres.

2.3.1 Bulgaria

In Bulgaria, the distributors' and wholesalers' have a deposit account which is managed by the credit control department. With this, it is possible to see how many returnable assets, and their value, are owed to Carlsberg by each client, at every moment. If the credit limit is exceeded, the distributor or wholesaler must pay or return the assets they have on their account, however, they can't return more than the ones they have in the account. Furthermore, at Carlsberg's distribution and redistribution centres, the returns are checked and the lost empties are invoiced to their clients.

This measure improved the return rate and reduced the sorting cost, aided to follow the returnable assets movements through the market and reduced the percentage of lost empties to, approximately, 5% per year.

Another good practice of Carlsberg Bulgaria and two other major breweries on the market is the bottle and keg exchange. When two of the biggest breweries have collected enough of each other empties to fill one truck, they exchange them. This is only valid for currently on market bottles, thus, no one receives unusable assets on these trades, and allowed a reduction of costs and lost assets to all parties.

2.3.2 Croatia

In Croatia, the market has a high keg demand volatility due to overstocking before the Summer and the events, thus, holding this refillables longer and lowering their rotation. Their activity uses the 30L kegs as the main SKU while the 50L ones are used as support.

In order to fight this issue, Carlsberg Croatia started to limit distributors stocks according to their sales and replaced some of the 30L kegs for 50L on their clients according to their location, storing conditions, target public and sales' volume and variability.

Additionally, a keg inventory was performed with the physical count of all 30L and 50L kegs on Carlsberg's own distribution centres, their distributors' warehouses and an estimated count at each sales point.

All these good practices allowed Carlsberg Croatia to improve their kegs' rotation and their stocks transparency.

2.3.3 Estonia

In Estonia, returnable glass bottles were treated as any other material on the market, and bottle collectors were able to sell most of them to the highest bidder, hence, affecting the overall return rate of refillables to below 80%. Furthermore, the introduction of European Union's demand driven mandatory packaging recovery rates in 2005 posed a threat to start paying packaging excises for the not collected packaging amounts.

As a good practice, a deposit system was implemented since it was seen as the only possible solution to fulfil the obligatory packaging waste collection rates in a cost efficient way, in markets with low environmental awareness.

It allowed Carlsberg Estonia to raise their empties return rate to approximately 95%, and to achieve the mandatory packaging recovery rates, thus, no extraordinary taxes were paid.

2.3.4 Finland

In Finland, the Winter's sub zero temperatures result in high breakage rates of the glass bottles stored outside, due to the frozen water inside them and the ice stuck on the crates. Even the scuffing processes aren't always efficient and a high amount of these vessels break.

The solution applied to this issue was to convert the outside storage in warehouses, though, simple and cheap ones. Therefore, a total area of 20 280m^2 was covered with big and sturdy tents, thus, preventing the snow and rain from reaching these assets and reducing both the breakage rates and the investment required. One of these tents can be seen in Figure 2.9.

Figure 2.9: Carlsberg Finland's covered outside storage.

Additionally, Carlsberg Finland is part of the non-profit organisation Ekopullo since 2004 whose purpose is to manage and optimise the bottle's and retail packaging materials' conditions. It also is responsible for ensuring that its members have sufficient supply of empty beverage packing units. So, its continuous goal is to improve the empties' refilling rates and reduce produced the waste.

2.3.5 Germany

In Germany, the trucks' trailers used to deliver and retrieve products and vessels were only accessible through their bottom, which was highly inefficient. Additionally, it wasn't possible to reach their maximum loading capacity, when delivering finished products, due to weight restrictions applied to the vehicles in circulation, and it wasn't also possible to retrieve all of the customers empties, as they often want to return more than they have received initially.

Therefore, the solution was to acquire new trailers with side curtains and more space to expand its accessibility and allow the retrieval of all returnable assets. These can be seen on Figure 2.10.

Figure 2.10: Carlsberg Germany's new trucks for product delivery and assets retrieval.

With this investment, Carlsberg Germany managed to retrieve 50% more empties per transport and saves one round trip by stacking pallets with empties on top of each other.

2.3.6 Greece

In Greece, the usage of four different returnable glass bottles types and five crates, along with their mixture with the competitors' vessels, poses a complex challenge and, if they aren't sorted properly, result in significant drops of the OEE.

As a good practice, Carlsberg Greece started to receive their empties with a "to be reviewed" note and performs random checks upon arrival to ensure the quantity and quality of the returned bottles. On these random checks, if any missing or competitors' bottles are found, they are charged back to the client.

Additionally, an outsourced manual sorting of the crates, prior to supplying them to the filling line, is undertaken and its overall cost is lower than feeding the crates directly.

These measures aren't able to eliminate mixing in the crates of their own bottles, but can prevent losses and contamination with the competitors' ones.

As a result, Carlsberg Greece improved the filling line's OEE and health and safety (H&S) conditions, as well as lower the bottle losses rates.

2.3.7 Poland

In Poland, consumers habits to return bottles weren't satisfactory (return rate of 89%) because the deposit value is low, thus, not encouraging the clients to return the empties. This had a great impact on these vessels' availability for production, requiring high investments each year to replace the lost bottles with new ones.

Carlsberg bet on promotional campaigns, ecological driven promotions, the standardisation of the deposit fee logo on the bottles' label, the exchange of competitors refillables between breweries, and the implementation of a voluntary self-regulation agreement with an incentive mechanism for retailers and wholesalers, to instigate the interest in returning these assets.

With these good practices, Carlsberg Poland improved the return rates and the vessels' availability for production, and, consequently, reduced the required investment in new bottles.

2.3.8 Serbia

In Serbia, a low percentage of clients have more than half of Carlsberg's sales volume, and due to the end of the month push to meet sales objectives, the production lines lack the refillables. This critically affects the OEE because, from time to time, the factory is forced to stop producing, and urgent trucks are sent to the clients just to retrieve empties.

The good practice applied in this scenario was to schedule regular returnable assets retrievals in order to maintain a stock level nearly constant and healthy to the production lines.

This way, Carlsberg Serbia was able to increase their assets' return rates and their OEE, as well as decrease the transportation costs and use better the vehicles return routes.

2.3.9 Spain

In Spain, there's a high missing and mixed bottles on each crate, lowering the return rate to critical levels on several breweries. This also poses a problem to the transport companies, since only a part of each delivery truck with returned bottles is usable to each brewery. Therefore, they require more assets transports and overload the transporting companies' capacity.

In order to fight this issue Luís Simões, in partnership with the local breweries, implemented a manual verification process on their Madrid distribution centre. Its different stages are presented in Figure 2.11.

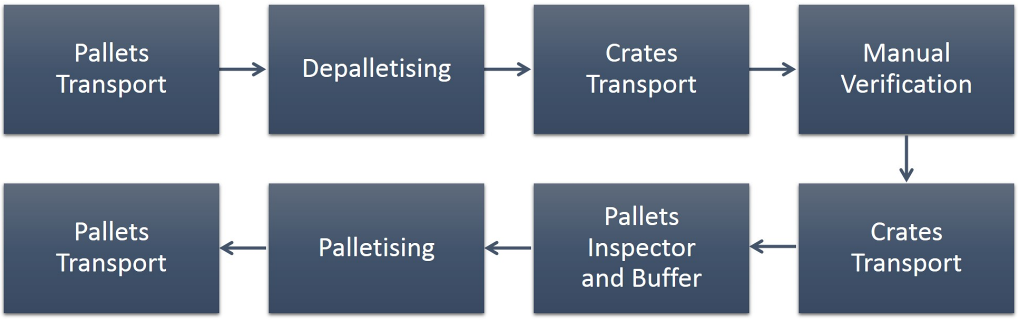


Figure 2.11: Luís Simões's manual verification process stages.

In the manual verification stage, the workers extract the foreign bottles and replace them with the correct ones. When the crates are excessively contaminated with undue bottles, they are separated for a classification apart from the main stream. At the end of this process, the client receives its deposit fees according to the verified amount at the inspection site.

An old filling line was repurposed to build this verification line. Therefore, the investment required wasn't high, and in only a three month period it was already paying-off.

2.3.10 Switzerland

In Switzerland, due to the high number of different bottles and crates being used, the returnable bottles end up in the wrong crates and the crates are mixed on the pallets, as seen on Figure 2.12. They have to be sorted out in order to be used at the filling lines.

Therefore, a manual sorting system was implemented where the pallets and crates are moved in conveyor belts, which can be seen in Figure 2.13. This process starts with a high-level verification to determine whether the crates have the right bottles or not and if not they are depalletised and proceed to the bottle sorting area.

Figure 2.12: Carlsberg Switzerland pallet with several mixed crates.

This allowed the Carlsberg Switzerland factory to reduce the sorting effort, the wrong bottle per crate rate and the risk of having issues in the filling line.

Figure 2.13: Carlsberg Switzerland crates and bottles sorting station.

2.3.11 Ukraine

In Ukraine, the Carlsberg factory isn't responsible for the empties' return. Instead, a separate company collects them from the clients and sells them back to the production plant to be refilled. This company is denominated as a tare operator.

The challenge faced on this case was the bad quality of the supplied bottles, where a significant amount of them (near 3.5% of the filling volume) would break.

The measures applied to fight this problem were the payment after filling, where the broken bottles wouldn't be paid to the tare operator, the constant presence of a reviewer from the supplier company to assess the bottles' quality and quantity, and the collaboration of the distributors with the tare operator to take advantage of their return trips for a compensation.

These good practices developed the relationship between all parties of the supply chain, improved the refillables' return rates and rotation cycles, and reduced the bottles' cost and inventory on Carlsberg Ukraine's books.

2.3.12 United Kingdom

In the United Kingdom, the high value of stainless steel makes beer kegs attractive targets to theft and destruction practices due to their high scrap value.

In order to fight this issue, Carlsberg started working more closely with its clients, scheduling the delivery hours to prevent the kegs from being left outdoors any longer than necessary. They also instructed the delivery personnel on the kegs' value and on how to retrieve assets safely, and started checking the delivery and retrieval vehicles, upon arrival, to rise the accuracy of the uplifted kegs' quantity. Additionally, Carlsberg joined Kegwatch, which is an organisation working to continuously improve the recovery of containers via liaison, with the licensed trade, beer wholesalers and pub companies.

Furthermore, with the Somersby cider brand launch, an ultra high frequency (UHF) RFID tag was installed on all 50L cider kegs to automatically separate the two types of kegs population and retrieve the market response to this new product more accurately. These new kegs can be viewed in Figure 2.14 and the portal readers installed on their Heathfield Way distribution centre can also be seen in Figure 2.15.

Figure 2.14: Carlsberg UK's new kegs with an UHF passive RFID tag.

Figure 2.15: Carlsberg UK's new portal readers at their Heathfield Way distribution centre.

These good practices taken by Carlsberg UK led to better kegs' return rate and lower replacements' investment, more transparency and awareness of the keg related processes, and the improvement of the market knowledge.

Chapter 3

Unicer's Supply Chain

In this chapter the path taken by Unicer's returnable assets since they are filled on the production line until they're retrieved and stored, waiting to be reused, is detailed. This course can be split in two opposite streams: the first one is denominated outbound logistics and represents all the steps taken by the product since it is being produced until it is delivered to the customers; and the second one is known as reverse logistics, or inbound logistics, and covers all the processes of retrieving the returnable assets back to the production facilities.

To collect all these informations and analysis.

3.1 Outbound Logistics

The Leça do Balio facility only produces and fills beers. The most produced one is Super Bock, followed up by Cristal and Carlsberg. Out of all beers produced by Unicer, only the three beer brands aforementioned use returnable glass bottles (RGB), while the other ones are sold in kegs or non-returnable glass bottles (NRGB).

This facility has seven filling lines, each working three shifts per day. Four lines work seven days per week during the whole year, and three work when required to cover product demand.

The layout of the returnable beer bottles' filling line (line #3) can be seen in Appendix B, where the green, brown and red lines represent the route taken by the pallets, crates and bottles, respectively.

3.1.1 Production

The returnable assets' cycle starts at the production facility when they are transferred from the storing allotments to the corresponding filling lines in pallets of bottle crates or kegs, waiting to be processed.

Once their turn has come, they are supplied to a platform by a forklift operator in order to be depalletised and, then, undergo a sorting process to separate the required bottles, crates and kegs from the undesired, foreign and damaged ones. Figures 3.1, 3.2 and 3.3 show the different stations where these actions are performed.

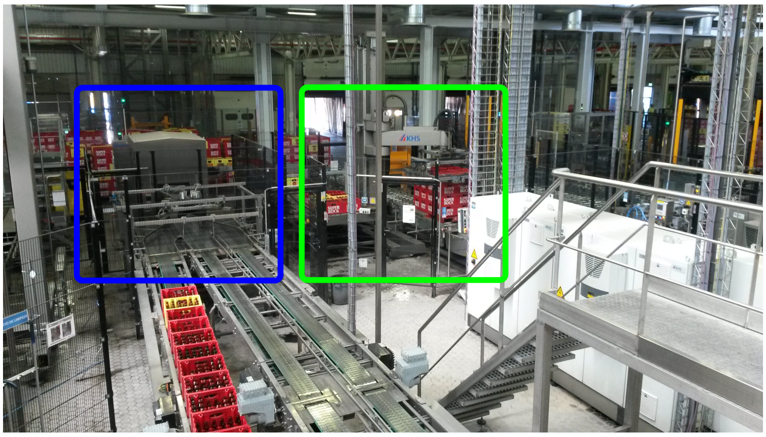


Figure 3.1: Crate depalletiser (in green on the right) and sorting station (in blue on the left).

Figure 3.2: Bottle sorting system's conveyors with two bottle classifiers.

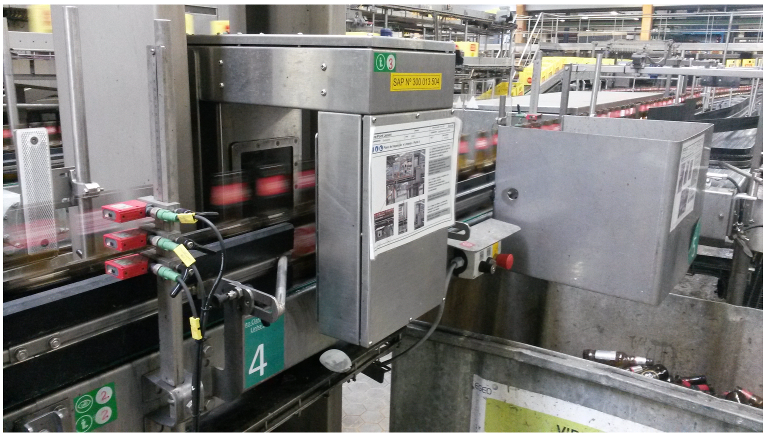


Figure 3.3: Bottle classifier with glass recycling bin.

The next step is the cleaning and drying process, with the assets being washed with hot water and chemicals to guarantee hygiene and safety standards of the products to the consumers. The bottles enter through the holes seen on Figure 3.4 and exit the equipment cleaned and dried on a conveyor belt, as seen on Figure 3.5.

Figure 3.4: Bottle washer and dryer.

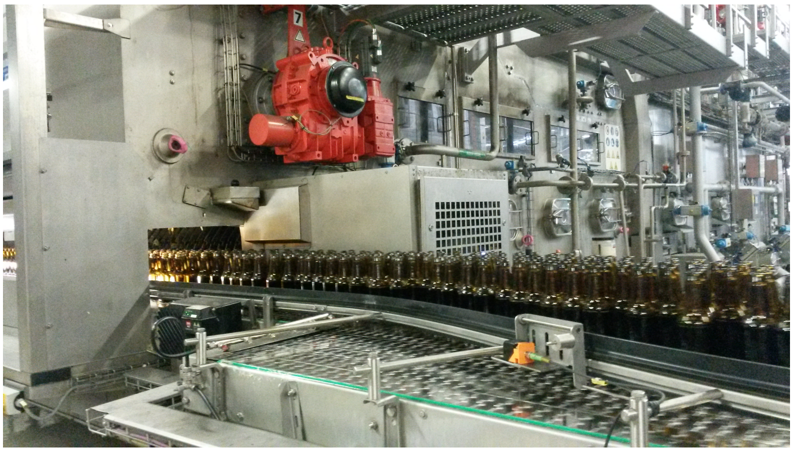


Figure 3.5: Clean bottles exiting the washer machine.

The following stages are the filling and pasteurisation ones (see Figures 3.6 and 3.7), where the bottles and kegs are filled, sealed and heated to eliminate most pathogenic microbes, thus improving the products' quality and prolonging their expiration date.

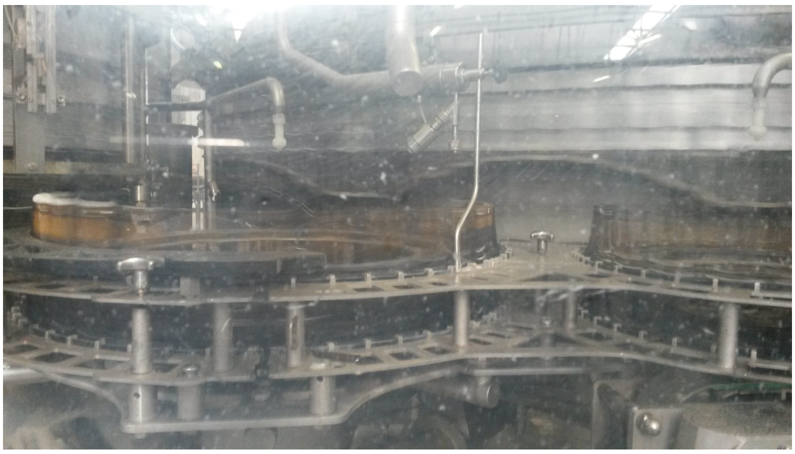


Figure 3.6: Empty bottles supplied to the filling machine (on the right) and full (on the left).

Figure 3.7: Filled and caped bottles being heated in the pasteuriser.

The filling lines' final processes are product labelling, packing, verifying, palletising and pallet labelling too, so that the finished product can be easily transported and processed. In Figures 3.8 and 3.9 two of these stages are shown.

Figure 3.8: Bottles' body and neck labeller.

Figure 3.9: Crates' loader (on the left) and colour sorter (on the right).

During 2014, Unicer unpacked, cleaned, filled, caped, labelled and packed 204 753 306 returnable beer bottles, depalletised, emptied, washed, loaded and palletised 7 860 625 beer crates, and depalletised, cleaned, filled, sealed, labelled and palletised 1 364 652 beer kegs.

3.1.2 Storage

At the Leça do Balio facility, once the product is finished, it is placed on an interface (see Figure 3.10) with the automated warehouse's monorail, that will store the final product until it is purchased by a client or moved to an external depot. The storing process is nearly fully automated at the Leça do Balio facility and it is supervised using warehouse management SAP applications.

Figure 3.10: Interface platform of the production line with the automated warehouse's monorail.

Unicer is focusing all its operations of beer products in bottles and kegs at the Leça do Balio facility, but until that transition is over it will keep using external warehouses. So, whenever the ownership of a product with returnable assets is transferred to another entity, be it a client or an external depot, a document is created to keep track of these movements and a deposit fee is required. Afterwards, these returnable assets' movements are viewed, monitored and managed by the logistics and operational planning departments resorting to the Vessels' Cockpit information system, a SAP application specifically developed for this purpose.

During 2014, Unicer collected 70 526 995€ and returned 71 017 491€ of deposit fees relative to returnable beer bottles, crates and kegs. This negative difference of 490 496€ is due to the market trend of the products using returnable assets, as well as the closure of several selling points and distributors.

3.1.3 Sales Organisations

Unicer sorts its sales in eight different organisations, most commonly known as channels, according to the clients' characteristics. Their names and sales volumes of beer products using returnable assets are presented on Table 3.1.

Table 3.1: Sales organisations' details

Code	Name	Sales Volume (kL)
D001	Distributors	77 155
D002	Retail	21 867
D003	Off Trade	13 848
D004	External Markets	2 516
D010	Marketing	59
D017	Organised Horeca	1 495

The distributors, retail and organised horeca clients are Unicer's main channels for selling the products with returnable assets, and form the on trade group of clients. Their deposit fees accounts increase and decrease according to their returnable assets movements, with the exception of 1 641 strategic clients that aren't charged for commercial reasons.

The 47 distributors spread around the country coordinate their operations in order to timely satisfy the market demand while maintaining their service levels.

The retail and organised horeca clients are the coffee shops, snack-bars, restaurants and hotels situated in Porto, Lisbon and Aveiro. Their stocks are closely followed by the commercial teams, which are responsible for creating new delivery orders and submitting assets' retrieval requests.

The off trade channel is formed by all categories of markets and grocery stores, where the final customers can acquire the products and take them home. Here, most clients prefer to buy products without returnable assets since their price isn't very different from the ones with refillables. Additionally, the biggest market groups often make attractive discounts to the products without returnable assets, making these more desirable to the final customers.

The distribution of the all supplied vessels to the different sales organisations, during 2014, is presented on Table 3.2.

Table 3.2: Sales organisations' details

Sales Organisations		Beer Bottles	Beer Kegs
D001	Distributors	77,2%	63,5%
D002	Retail	14,0%	28,3%
D003	Off Trade	7,7%	0,0%
D004	External Markets	0,5%	5,7%
D010	Marketing	0,0%	0,2%
D017	Organised Horeca	0,5%	2,3%

3.2 Inbound Logistics

Unicer's reverse logistics strategy is similar to a depot system with deposit fee except for the existence of a central agency. Instead of outsourcing it, and to comply with the portuguese law, Unicer manages its own returnable assets' park according to the market demand and company growth.

The return of the empty containers from the final clients' establishments, is the responsibility of who supplies them, which can either be Unicer or one of its distributors.

3.2.1 Retrieval

The assets' return phase starts when they are retrieved from the sales points and gathered at Unicer's facilities or depots and clients' warehouses, according to their source channel. The transport of these containers back to the production facilities is made by Unicer and its partners in heavy goods vehicles.

The distributors and the external markets' clients indirectly supply the final consumer and, so, they have their own delivery and retrieval network. Once they have enough containers to fill a truck, they alert Unicer, so that a retrieval request is generated and carried out. A document with the assets' SKU, description and quantities is printed and certifies the cargo's contents from the pick up point to the unload site. One of these documents can be seen in Appendix C. These trucks' cargoes are denominated as mono-client, and represent approximately 90% of all retrievals arriving at the Leça do Balio centre.

The remaining channels' clients, which are directly supplied by Unicer, don't have to wait until they have enough assets to fill a truck because the logistics department plans several tours of product delivery and empty assets retrieval. Normally, these customers aren't charged the corresponding deposit fee nor have it returned, unless they wish to change their stock level, because the delivery teams are instructed to bring back the exact same quantity of returnable assets as the one left at the clients. Therefore, the deposit fee they've been charged with, when they first acquired the products, is maintained.

The logistics department is responsible for scheduling the returnable assets delivery in order to prevent the occurrence of uncontrolled congestion periods and the idle periods as well.

3.2.2 Unloading and Storing

The first step of the unloading process starts at the logistics department, where the allotments to be used by the forthcoming returnable assets are chosen and the forklift operators instructed.

As the heavy goods vehicles arrive at Unicer's facilities, they enter on a first queue system to unload their cargo and a second one to be loaded with the finished products to deliver at the client's warehouse. Generally, these vehicles bring 28 to 32 pallets of returnable assets on each trip and, depending on the products' weight, leave with the same amount of pallets, so that all safety constraints are respected.

Once its turn has come, the truck is emptied, usually, by only one forklift operator, that holds two pallets at a time. This process takes around one hour, and, when finished, the client receives his deposit fee back. This is a service that, due its variability, is outsourced. Figure 3.11 shows a truck getting ready to be unloaded.

After the refillables have been stacked on the corresponding allotments, which can be seen in Figure 3.12, they will wait until they're needed back at the filling line, thus, starting a new cycle.

Figure 3.11: Truck with beer crates and 30 litters kegs waiting to be unloaded.

Figure 3.12: Open air allotments. Photographies taken at 10th February of 2015 (above) and at 26th May of 2015 (below).

During the last quarter of 2014, Unicer emptied 829 trucks and unloaded, carried and stacked 23 921 pallets.

Chapter 4

Returnable Assets Control Processes

In this chapter the most important processes that Unicer has implemented to control the quality and flow of its returnable assets are described. These occur during their whole cycle, beginning on the filling line, going through the market and finishing back at the allotments where they wait to be reused.

4.1 Filling Line - Crate and Bottle Sorting

Leça do Balio's returnable bottles filling line's first step is the sorting process, which is done in two stages.

The first one occurs right after the crates' depalletisation, to classify them in either good or bad. The criteria used is whether the crate contains, at least, half of its capacity of the required bottles. If it does have, it goes forward to an unload station where the bottles are extracted from the crates and placed on conveyor belts. If it doesn't have, the crate is deviated to manual sorting or automatic palletisation and storing, according to the production order and the bottles inside it.

This verification process resorts to an image processing algorithm that compares the bottles' shape and diameter against previously recorded ones of the required bottles for the current production order.

The second sorting stage is performed by two bottle classifiers, after the bottles have been put in two separate lines, to eliminate the bottle mixture and contamination of the final product with undesired or foreign bottles. It also prevents the interaction of any strange and dangerous objects with the upcoming filling line's equipments.

Unicer's undesired bottles, for the active production order, are gathered, manually palletised and stored to be used again on the proper production order. The foreign or damaged bottles are scrapped, and their glass is recycled by Unicer's suppliers.

This verification process also resorts to an image processing algorithm that measures the bottle's height and compares it with the bottles used by Unicer to determine whether to let it continue to the next stage, to separate it for another production order, or to destroy it.

These sorting equipments have a user interface to present live statistics and allow the operators to change their settings, according to the production order, which can be seen in Figure 4.1.

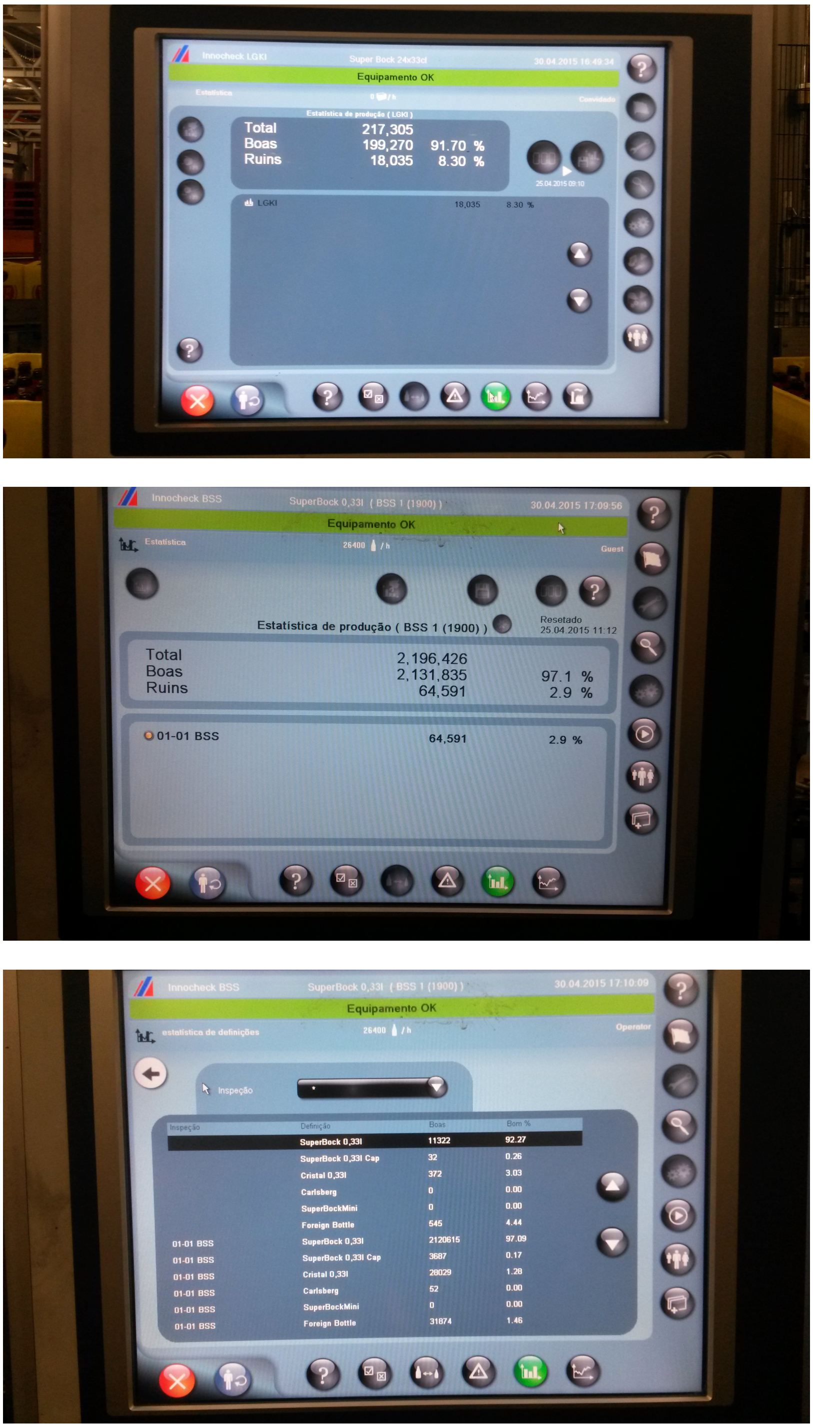


Figure 4.1: Crates (first) and bottles (second and third) sorting stations' user interface with statistics of an ongoing Super Bock 33cl production order.

4.2 Filling Line - Conveyor Belts Adjustments

Once the bottles have been extracted from the crates they are transported along the filling line's equipments through conveyor belts. These have several control units spread along the line's different stations allowing the operators to change their speed settings according to the production order type and quantity.

This control provides the filling line with the required adaptability to use bottles with different dimensions, weights and thicknesses.

Along with the possibility of changing the speed settings of the conveyor belts, the walls that route the glass bottles are also adjustable by manually tightening a screw on their outside.

These controls are continuously tested and their results measured in order to improve the filling line's efficiency and lower the breakage rates of the whole production process.

4.3 In Traffic - Mobility System

Unicer's Mobility system is a SAP application developed by the Information Systems Department, in 2009, specifically to assist the commercial and delivery teams that work closely with the retail clients.

It processes the purchase orders and assets' return requests inserted by the commercial teams, and generates delivery routes that are later assigned by the logistics department to the corresponding two-person teams.

Through a portable digital assistant (PDA), this system informs the delivery teams of their route, the products to supply each client with and the returnable assets picking requests. Not only that, but it also allows them to rectify the quantities and types of the products being delivered and the containers being retrieved from the clients' establishments. Therefore, at the end of each delivery, a receipt with the correct information is printed, on a mobile printer, and attached to the original invoice, so that the client proceeds with the payment.

When the delivery route is finished, two summaries are printed. One containing the cargo contents, i.e., the returned glass bottles, crates and kegs, the undelivered products and any exceeding products that were mistakenly loaded before starting the route. The other summary is a list of all the payments received by the delivery team and all deposit fees returned by it. An example of these two summaries can be seen in Appendix D.

4.4 In Traffic - Vessels' Cockpit

The Vessels' Cockpit is also a SAP application developed by the Information Systems Department, in 2011, to support the operational planning team on managing the clients' stocks and movements.

It is an aggregation system that fetches several documents from different sources, extracts their important data and shows it in a single table according to the filters applied by the user. This information assists the stock management technicians on their tasks, which involves planning the retrieval of the assets in possession of Unicer's clients, in order to guarantee their availability for the production orders. With it, is also possible to analyse the market's flow and tendencies by comparing different periods of time, to check for discrepancies on the stock levels, and to obtain custom reports.

This system's layout can be seen in Appendix E, allowing the users to set the desired date interval, sales organisation, materials' SKUs, and other analysis criteria regarding the clients' purchase details to filter the available information.

4.5 In Traffic - Unidis

The Unidis project is an initiative of the information system's department that started earlier this year (2015). Its goal is to boost the overall performance of all operations involving the distributors by implementing the SAP system on them. At the time this thesis was written, 12 distributors already had the system implemented and on working conditions.

This will allow, among other things, to follow more closely the clients' stock levels of both products and returnable assets, providing Unicer with the means to retrieve them more timelier and with less resources, thus, optimising the routes' schedules and courses, and improving the vessels' availability during the high season.

4.6 Storage - Vessels' Reception and Storage

At Leça do Balio's facility there are two verification processes to control the returnable assets stock.

The first one is performed when a truck arrives at the unloading site to be emptied. Here, the quantities of crates and kegs being delivered are verified. If there aren't any discrepancies between the information present on the document that the driver brings with him since the truck was loaded and his cargo, the forklift operator starts unloading the pallets. Otherwise, the document is rectified and signed by both parties before continuing. At this stage, all bottle crates are assumed to be full, thus, increasing their stock levels accordingly.

The second verification process is carried out at the end of each day where a person counts how many returnable assets of a specific type are at the allotments. Each day, this person counts a different type of crates or kegs and rectifies their quantities on the system. For those cases where the crates are noticeably empty, the amount of glass bottles that were supposed to be inside them is subtracted to their stock level too.

Chapter 5

Identified Problems

In this chapter the most relevant problems that were identified on the supply chain's control processes are described, their impacts measured and their causes enumerated.

This was the starting point to search for specific improvements and solutions that would be able to enhance Unicer's processes and minimise their flaws.

5.1 Filling Line - Sorting Data Unavailability on MES

The manufacturing execution system (MES) is the returnable bottles' filling line control software that allows the user to view real time and historical data from its different control stations. It is used to measure the OEE, to view the current state of the different machines, to alert the occurrence of an unexpected situation, to generate time and quantities reports, and much more useful informations relative to the production processes.

When it was designed and built by KHS, its focus was the filling line's efficiency rates, thus, the information relative to the market's performance on correctly returning the glass bottles isn't accessible from it and isn't recorded as well. This problem's impact is that Unicer doesn't have the means to know, with certainty, how many missing and undue glass bottles enter in the production line, and, thus, it can't assess their consequences at any given time or period.

This mixture of Unicer's bottles with foreign ones may affect the line's performance, since it recurrently stops the supply of new crates to the filling line and jams up to three equipments responsible for the extraction of the bottles from the crates and for sorting system, as can be seen in Figure 5.1.

The bad crates stop the line's supply when enough of them are waiting to be manually processed, thus, triggering a sensor informing the crate sorting system that their conveyor is full. As a precaution measure, the crate supply system stops until this trigger is no longer active.

The mixed foreign bottles are also responsible for several jams of the equipments prior to the bottle washer. Since these bottles' characteristics are different from the ones that the line is prepared to deal with, they often fall and break, exposing these equipments to unexpected and, sometimes, dangerous situations.

Figure 5.1: Jam at the sorting classifiers' exit due to bottle mixture.

5.2 Filling Line - Carlsberg Bottles' False-Rejection and Breakage

The returnable glass bottles' filling line was initially designed to process Super Bock's and Cristal's brands. Therefore, when it was decided to use this line to also fill Carlsberg, a series of adjustments were necessary.

Unfortunately, even with all the alterations and new configurations made, a significant quantity of Carlsberg bottles are still incorrectly rejected by the sorting system's bottle classifiers and fall on the conveyor belts causing some abnormalities to occur along the filling process.

These incompatibility issues provoke the interruption of the production process, the loss of a considerable amount of bottles in good conditions (see Figure 5.2) and increase the risk to the operators, since these bottles break more often and their broken glass may cause injuries.

Figure 5.2: Scraped Carslberg bottles rejected during the sorting process.

The high false-rejection and breakage rates provoke unnecessary investments in new bottles. During 2014, 596 640 new Carlsberg 25cl bottles were acquired for 41 526€ to replace the ones that were lost in the market, the ones false-rejected at the sorting system and to cover the market demand.

5.3 In Traffic - Mobility System's Data Inaccuracy

The Mobility system relies on the information introduced by the commercial teams to plan the routes to be taken by the delivery teams, which don't only deliver but also retrieve the returnable assets from the clients' establishments.

The quantity of assets to be picked up on each route is equal to the quantity of assets being delivered, as explained in section 3.2.1, plus the ones from the return requests, which are estimated with a high inaccuracy rate by the commercial team that visited the sales points and issued the request.

In order to guarantee that the heavy goods vehicles have enough space for all assets being retrieved, the commercial teams round their numbers up. This is a good practice but isn't the optimal one because a lot of the truck's capacity ends up not being used.

The reason why this data is inaccurate is, in most situations, the clients' storage conditions that don't allow a simple and direct way of counting these assets prior to their retrieval. These conditions are the mixture of Unicer's and the competition's bottles, crates and kegs, and the high quantity of assets that some clients store for years.

5.4 In Traffic - Lack of Traceability

The ability to know where are the returnable assets, and exactly which ones, provides the managing departments with important information regarding their population and losses, market rotation, fill to return time and the time spent between two fillings.

These are all valuable metrics in order to plan the business's operations, and, at Unicer, they are estimated with a high satisfiability level by analysing the assets movements through the Vessels' Cockpit reports and the variations of the deposit fees' accounts, allied to the technicians' experience.

Therefore, Unicer is already aware of where their assets are, they just don't know which ones are they because the refillables aren't individually identified. This information is relevant for commercial and marketing purposes, by helping to identify product flows, and to mitigate the effects of transferring vessels between channels. This phenomenon occurs when a returnable asset is delivered back to Unicer by a client which wasn't the one that received it in the first place, and it's practically impossible to prevent it from happening since the market isn't restricted.

The absence of an assets' individual identification control causes the perpetuation of the transferred vessels' deposit fees, since the fees that were returned to the client that delivered the assets, weren't the ones received by Unicer when the first client acquired the products. Consequently, the first client's deposit fee is maintained until he delivers the corresponding assets, which he doesn't possess anymore. Additionally, the public tax entity stated that, if the assets haven't returned after two years, they won't return at all, hence, their deposit fees are actually an ownership transfer, which requires the payment of taxes (Value-Added Tax and Corporate Income Tax).

This wouldn't pose a big problem to Unicer if the assets wouldn't ever be retrieved, but what happens on most cases is that they've been brought back through another channel and a deposit fee has been returned to the client, though not the proper one.

5.5 In Traffic - Missing and Undue Glass Bottles

All returned crates are assumed to be full with correct bottles, unless stated otherwise on the document brought by the driver during the vessels' reception process. However, this is not true, there's a percentage of missing and undue bottles on those crates. The undue bottles can be either non-returnable glass bottles or the competition ones.

Figure 5.3 is a photo of a Super Bock 33cl crate with mixture of returnable and non-returnable bottles. The most direct way to identify the undesired bottles in this case is to analyse the bottlenecks. If it has only one long ring (on the right, highlighted in green), it is a refillable bottle. Otherwise, with a double-ringed neck (on the left, highlighted in red), it isn't proper to refill and shouldn't have been returned at all.

Figure 5.3: Super Bock 33cl returnable and non-returnable bottles inside a returned crate.

Figure 5.4 shows the empty spaces on beer crates from three different production orders, Super Bock 33cl, Carlsberg 25cl and Super Bock Mini 20cl. On both Super Bock fillings the crates were only half-full but the positions they occupy don't indicate an attempt to disguise their lack. However, on the Carlsberg's bottles are placed strategically to occupy the spaces near to the hand grips, which are the only way to view the crate's inside when they are palletised.

Figure 5.4: Super Bock 33cl, Carlsberg 25cl and Super Bock Mini 20cl crates with missing bottles.

This loss results on the incorrect return of deposit fees and, later, on the need to acquire new ones to replace them.

During 2014, the 33cl, 25cl and 20cl returnable beer bottles loss percentage was of 5%, with 3.5% estimated to occur on the market. In order to corroborate this loss percentage, some measurements were performed during the second quarter of 2015, and the result was an average loss of, at least, 3.82%. This assessment was manually done by adding the quantity of foreign bottles scrapped at the sorting station and the empty spaces on the crates. To calculate the percentage of missing bottles a comparison between the quantity of supplied crates and the total bottles sorted was made. Thus, the resulting equation to calculate the total loss is as presented in 5.1.

$$Total\ Loss(\%) = \frac{Foreign\ Bottles + (Good\ Crates * Capacity - Total\ Sorted\ Bottles)}{Good\ Crates * Capacity} \tag{5.1}$$

Throughout 2014, 208 430 490 of these bottles were retrieved by Unicer and, so, 7 295 070 bottles had their deposit fees incorrectly returned, since their crates weren't full of Unicer's returnable beer bottles. As it can be seen on Table 5.1 the deposit fee of each one of these bottles is 0.07€, thus, the missing and undue bottles have a direct cost of 510 655€ on the deposit fees' account.

By applying the 3.5% loss to each one of these bottles' pallets and multiplying that quantity with the bottles' deposit fee, it is possible to assess the loss per pallet, as seen on Table 5.2.

Furthermore, the majority (87%) of these lost returnable beer bottles (of 33cl, 25cl and 20cl) was required in the production line and, for that reason, 6 323 742 beer bottles were acquired for 562 559€ to replace them. Table 5.3 agglomerates all these informations.

Table 5.1: Beer bottles' and crates' deposit fees

SKU	Description	Deposit Fee
1001220	Super Bock and Cristal Bottle 20cl	0,07 €
1001225	Carlsberg Bottle 25cl	0,07 €
1001033	Super Bock Bottle 33cl	0,07 €
1001133	Cristal Bottle 33cl	0,07 €
1005024	Super Bock and Cristal Medium Crate (24 x 33cl bottles)	2,00 €
1005030	Super Bock and Cristal Small Crate (30 x 20cl bottles)	2,00 €
1005230	Calrsberg Beer Crate (30 x 30cl bottles)	2,00 €

Table 5.2: Beer bottles' loss per pallet of each product

Product	Crates	Bottles	Missing or Undue Bottles	Loss
Super Bock 33cl	48	1152	40,3	2,82 €
Carlsberg 25cl	56	1680	58,8	4,12 €
Super Bock Mini 20cl	64	1920	67,2	4,70 €

Table 5.3: Lost and replaced beer bottles in 2014

	Quantity		Value	
Bottle Type	Lost	Replaced	Lost	Replaced
Beer Bottles 33cl	4 435 800	3 464 472	310 505 €	331 098 €
Carlsberg Bottle 25cl	313 710	313 710	21 960 €	21 834 €
Beer Bottles 20cl	2 545 560	2 545 560	178 190 €	209 627 €
Totals	**7 295 070**	**6 323 742**	**510 655 €**	**562 559 €**

By adding the value of the incorrectly returned deposit fees and the cost of the new bottles bought to replace the ones missing, it is concluded that, in 2014, the missing and undue returnable beer bottles problem resulted in a total cost of 1 073 214€.

5.6 In Traffic - Deposit Fees' Account Reinforcements

The variations made to the deposit fees' values, along with the transfer of returnable assets between the channels, the perpetuation of deposit fees and the missing and undue bottles, explained in sections 5.4 and 5.5, cause a downward trend on the deposit fees' account that needs to be compensated with capital injections. So, over the past few years, several reinforcements have been undertaken in order to maintain the account on an acceptable and realistic level.

Figure 5.5 presents the deposit fees' account values along the past eleven years, and highlights the capital injections in red bars, allowing a more comprehensive overview of its evolution.

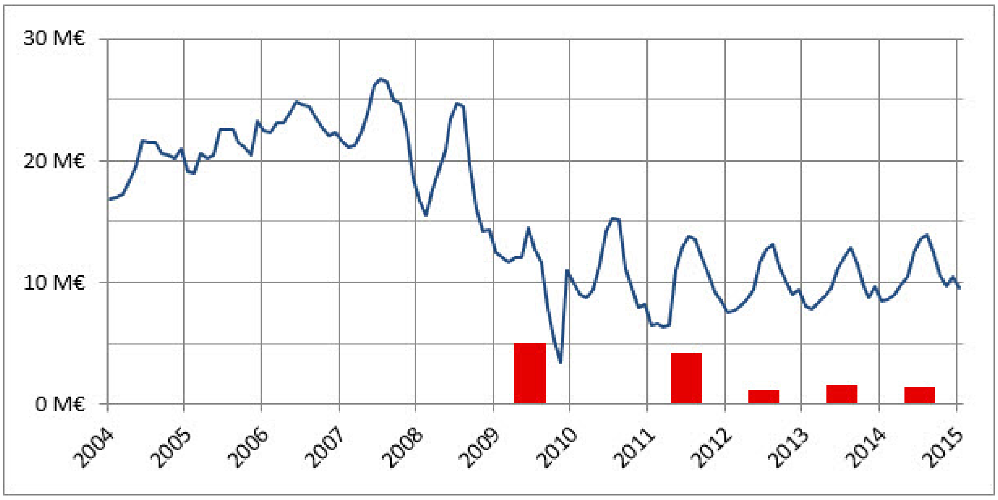


Figure 5.5: Deposit fees account values' evolution (in blue) and required reinforcements (in red).

By increasing the deposit fees to five times their previous value, Unicer encouraged the clients to return its assets more actively. However, it also provoked the account's value to drop lower and lower each year. It is visible that this trend has stoped since 2011 but that was only possible due to the continuous reinforcements being made each year, otherwise, the account's value would already be below zero.

During each year's second and third quarter, it is visible a rise on the deposit fees' account value because of the high seasonality of the beverages' industry and all the Spring and Summer festivals that take place.

On late 2009, when the deposit fees' account reached a value of 3 472 051€ the company had to inject 5 000 000€ in it. And later, in mid 2011, after dropping to 6 375 620€, Unicer, once again, raised its value with another substantial injection of 4 200 000€. These two reinforcements are considered to be correctional costs of the returnable assets' inefficient control processes until 2009, and so, the forthcoming capital injections to the deposit fees' account were due to expenses of working with refillables and required to be contemplated on Unicer's yearly budget.

In the past three years, these reinforcements were made monthly totalling more than 1 000 000€ each year, up to 3 901 000€ over the three years period.

Chapter 6

Proposed Improvements

In this chapter are described the proposed improvements to Unicer's processes, in order to fight the problems' impact and sources presented on the previous chapter. Their benefits and disadvantages are detailed, as well as the implementation and maintenance costs for most of them.

Furthermore, a business case was prepared with the most interesting improvements and was scheduled to be presented to Unicer's executive board on the 27th July of 2015. However, due to the Unicer's CEO sudden replacement, on the 23rd July of 2015, this presentation was postponed to late August or early September of 2015. It is expected that, on this executive board session, it is decided which of the proposed improvements will be implemented, so that the costs of handling returnable assets are minimised, and Unicer's competitiveness in the market is improved.

6.1 Filling Line - Adapt the Filling Line to Carlsberg's Bottles

The first improvement presented is to fully adapt the filling line to the Carlsberg bottles' characteristics.

In order to do so, several adjustments to the conveyor belts' speed and walls, and to the image processing algorithms and libraries are needed. Unicer is aware of these requirements, and already began to adapt the different equipments to this bottle's specifications.

An audit to the line's performance with a production order of Carlsberg 25cl has been carried out to assess the need for an intervention. Furthermore, new speed settings have been programmed for most conveyor belts, and the sorting system's bottle classifiers are in a test phase for this type of bottle too.

This study's lost bottles cost evaluation during a 25.7 hours period was of 1 691€, and it supported the continuous improvement department in assessing the need to apply these measures.

6.2 Filling Line - Monitor the Market's Retrieval Performance

Another filling line's improvement is the ability to record and analyse the processed information on its sorting system, just like it is already done on other stations, through the MES.

The advantages of doing so, is to completely analyse all variables within the filling process and give Unicer the tools to monitor the market's retrieval performance with the utmost reliability. The only downsides of this improvement is the necessary virtual space for storing all this data, which can rapidly reach several terabytes, and the increase of the quantity of information being handled by the MES software.

Additionally, this could led to an automatic monitoring of the market's performance when returning the assets, and the generation of alerts and customized reports to easily inform anyone.

At the time this thesis was written, this improvement was already being scheduled to implement, once the necessary resources are free.

6.3 In Traffic - Verification of Missing and Undue Glass Bottles Inside Each Crate

The most appreciated proposal improvement by Unicer's department directors is the verification of missing and undue glass bottles inside each crate upon the arrival of the retrieval truck, so that their deposit fees aren't returned to the clients. This is something that Luís Simões has already implemented in Spain with the local breweries, as described in subsection 2.3.9.

To implement such a measure at Unicer, first, it is required to assess the expected savings. This verification process requires that the inspected truck's cargo is mono-client, so that there aren't any doubts about who failed to deliver the refillables and to whom that cost is going to be imputed. Thus, this is an improvement only applicable to 90% of the assets' retrieval movements.

In this proposal, there are three possible scenarios to be considered:

- Manual depalletisation + manual verification + manual palletisation
- Automatic depalletisation + manual verification + automatic palletisation
- Automatic depalletisation + automatic verification + automatic palletisation

6.3.1 Completely Manual Setup

The completely manual setup, with the current service provider, costs 0.03€ per bottle, which is equivalent to 34.56€ per Super Bock 33cl pallet, 40.32€ per Carlsberg 25cl pallet, and 46.08€ per Super Bock Mini 20cl pallet.

By comparing these processing costs with the loss of having missing and undue bottles on the crates, presented in Table 5.2, it is concluded that the completely manual scenario isn't profitable, due to the service provider's price per bottle.

6.3.2 Manual Verification with Automatic Depalletisation and Palletisation

The manual verification with automatic depalletisation and palletisation has a manual labour cost of, approximately, 20 000€ per year per person, an equipment acquisition cost of, approximately, 300 000€.

This hybrid implementation allows the inspectors to spend less time on support tasks and focus on verifying the crates' contents, thus, improving the whole process's capacity and simplifying it. This setup is similar to the one performed by Luís Simões in Spain, which had its payback in only three months because they repurposed all the equipment used.

Some simulations of this scenario were performed on MathWorks® Simulink® with resource to its SimEvents library to assess the time spent on this procedure.

This setup achieved an overall processing time of 1 hour and 10 minutes to verify 16 pairs of pallets, which is the maximum load of the retrieval trucks. The line graphs in Figures 6.1 and 6.2 demonstrate the evolution of the queues' sizes with two different capacities of the unloaded pallets queue. The red line illustrates the pair of pallets on the truck, waiting to be unloaded. The green line represents the pair of pallets on the conveyor belts, waiting to be verified. The blue line shows the pair of pallets waiting to be stored. The purple line demonstrates the quantity of crates (in pair of pallets) waiting to be verified. And the brown line illustrates the number of crates waiting to be palletised.

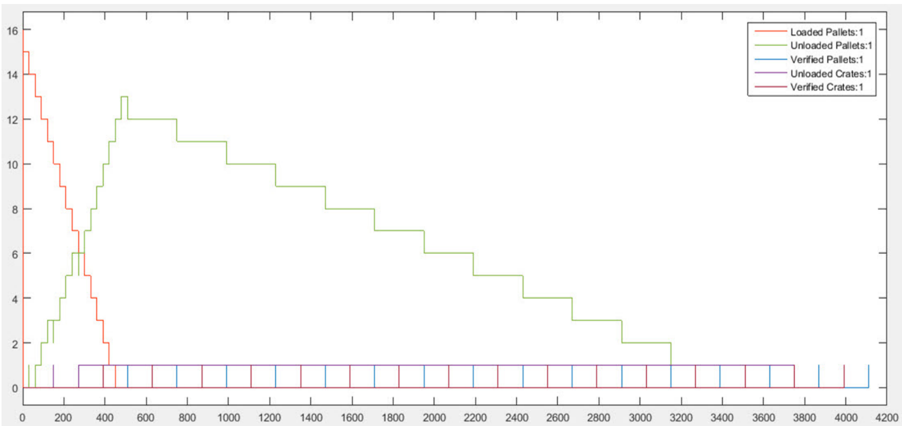


Figure 6.1: Manual verification scenario queues' sizes with one forklift, four servers and unlimited conveyor belts, each carrying two pallets at a time.

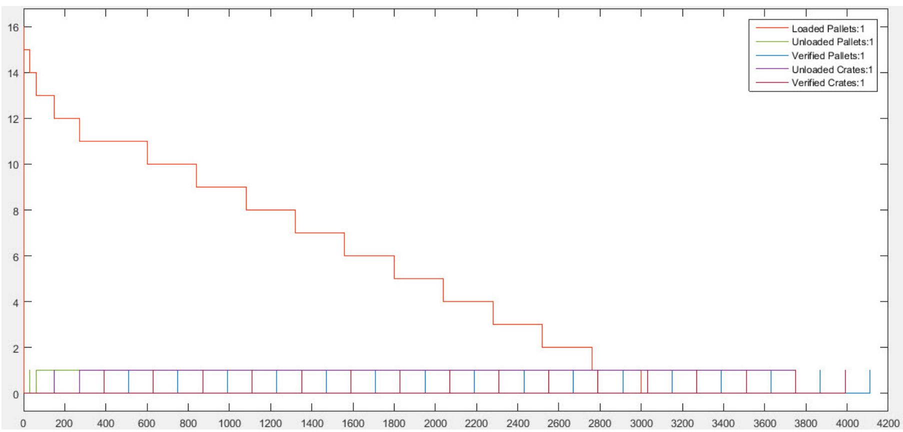


Figure 6.2: Manual verification scenario queues' sizes with one forklift, four servers and one conveyor belt, carrying two pallets at a time.

The tasks' processing times were measured at Unicer on very similar procedures, and their average time was used for this simulation.

Furthermore, since there is only one forklift unloading each truck, there's a decision phase on this model, where the operator has to choose between continuing to unload the truck or to store the already verified pallets. The decision criteria used was to always prefer to store the already verified pallets before continuing to unload the truck, as long as there is at least one pair of pallets waiting to be processed.

Additionally, since only one depalletising and palletising robot is being used, there's also another decision phase, where the robot is programmed to process the verified crates before introducing new ones on the verification conveyor belts.

The whole process' bottleneck was identified - the verification stage - to study which decision criteria to apply.

6.3.3 Completely Automatic Setup

The completely automatic setup has a maximum acquisition cost of, approximately, 550 000€.

This human-free verification option is less susceptible to errors and, in general, is better accepted by the clients. There's still a small false-rejection error on this kind of verification processes, which has to be considered as the margin by which the clients wouldn't be imputed.

The extent of any of these scenarios can go from only verifying the return rate of each client, to replacing the wrong bottles with the correct ones. However, since a sorting system already exists at the beginning of the filling line, which is efficient on removing the foreign bottles and capture the Unicer's wrong bottles for the current production order, this verification process focuses on minimising the incorrectly returned deposit fees. This way, it is as simple, fast and inexpensive as possible.

With this in mind, two possible automated setups were studied. The first one is as minimalist as possible, where the pallets are placed on a conveyor belt to be verified, depalletised and palletised with only one robot and one crate verifier mechanism. On this case, the verification would need to be done to each crates' layer of the pallet, and the palletiser would stack each one of them right after depalletising them. The second one is slightly bigger, thus requiring more space, involving one depalletiser and palletiser robot and one individual crate verifier. This way, the crates are put in a straight line to be processed, and then palletised, as in the layout present on Appendix F, where the green equipments are responsible of the pallets' transport and the yellow conveyor belts of moving the crates along the verification line.

The first and minimalist one achieved an overall processing time of 35 minutes and 30 seconds to verify 16 pairs of pallets, which is the maximum load of the retrieval trucks. The line graphs in Figures 6.3 and 6.4 show the evolution of the queues' sizes with two different capacities of the unloaded pallets queue as well. The red, green and blue lines have the same meaning as on the previous scenario.

The second and medium one achieved an overall processing time of 40 minutes and 30 seconds to verify 16 pairs of pallets. The line graphs in Figures 6.5 and 6.6 demonstrate the evolution of

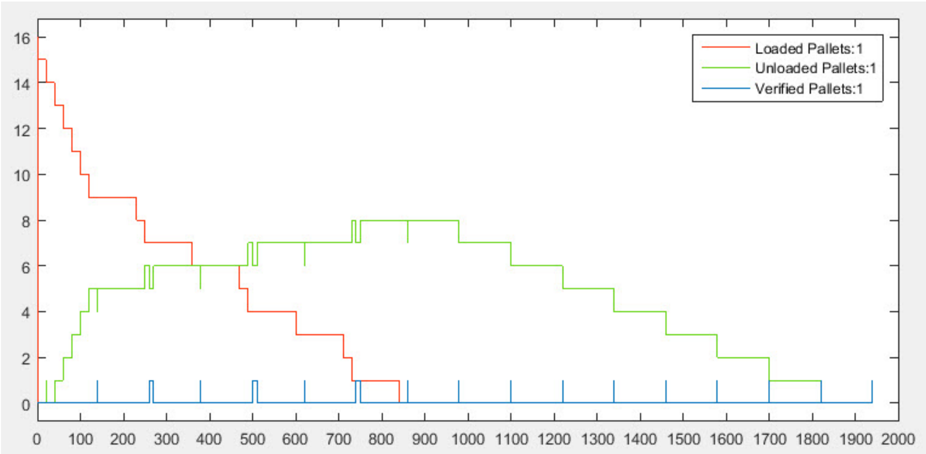


Figure 6.3: Minimalist automatic verification scenario queues' sizes with one forklift, one server and unlimited conveyor belts, each carrying two pallets at a time.

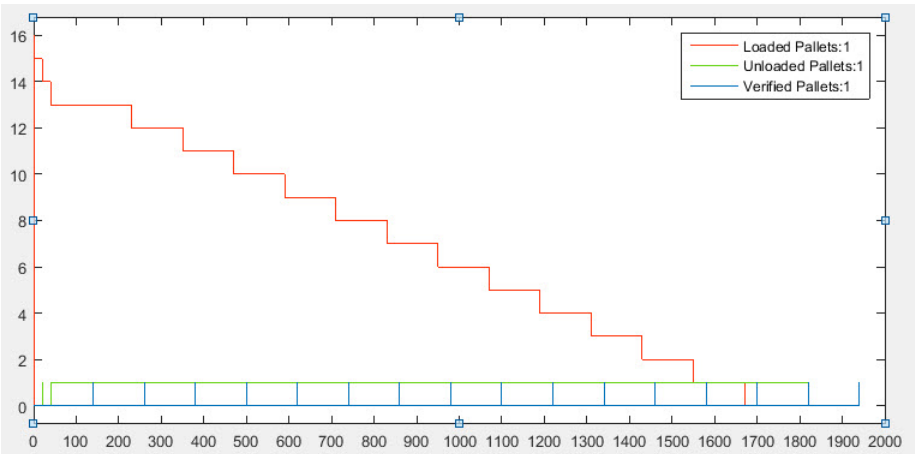


Figure 6.4: Minimalist automatic verification scenario queues' sizes with one forklift, one server and one conveyor belt, carrying two pallets at a time.

the queues' sizes, also with two different capacities of the unloaded pallets queue. The coloured lines have the same meaning as on the completely manual scenario. The same strategy applied on the previous scenario was used on this one, to assess the tasks' processing time and to solve the decision question.

6.3.4 Scenarios Summary

With these scenarios simulations, it is concluded that the utilisation of more conveyor belts to unload the truck's pallets doesn't affect the overall processing time. Thus, there isn't a direct need to use more than one conveyor belt for the unloaded pallets. However, it is recommended to use at least two of them to guarantee the continuous working flow of the verifying equipment, due to possible delays that may occur during the truck's unloading and pallets' storing processes.

These simulations' models can be viewed on Appendix G.

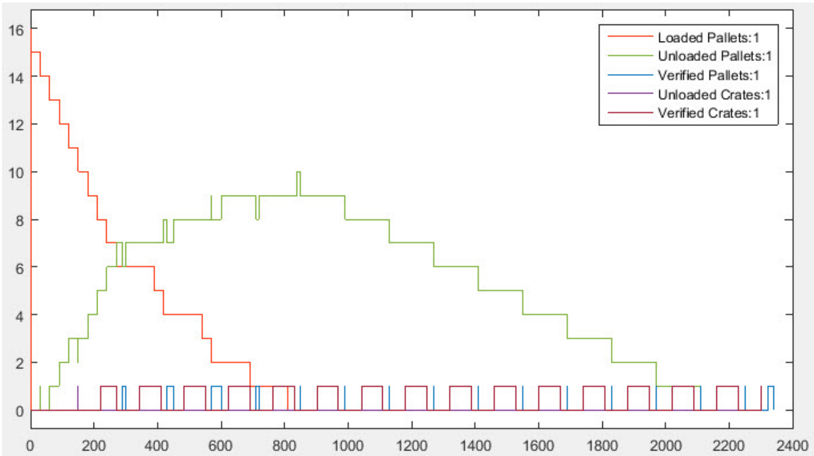


Figure 6.5: Medium automatic verification scenario queues' sizes with one forklift, one server and unlimited conveyor belts, each carrying two pallets at a time.

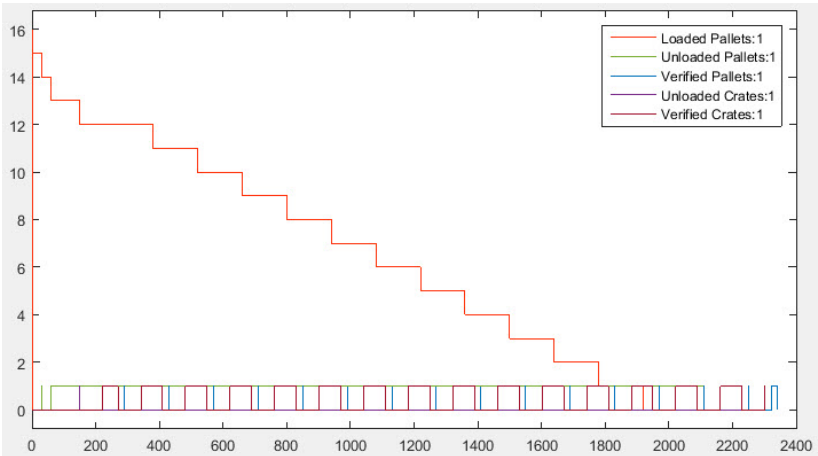


Figure 6.6: Medium automatic verification scenario queues' sizes with one forklift, one server and one conveyor belt, carrying two pallets at a time.

The investment required for these alternative scenarios depends on the company's assets, because most of them can be recovered and repurposed into building a verification line. In Unicer's case, there is a couple palletiser and depalletiser not being used in a production centre in Santarém, which can be reallocated to the Leça do Balio centre to fit these scenarios. Besides these two machines, there are enough conveyor belts available too, which can assist the pallets and crates movements. The only equipment not yet available is the crates' verifier, which would have to be acquired.

However, at Unicer, these equipment investments and repurposes follow a standard procedure involving the continuous improvements department, which, after having received these possible scenarios, with the already assessed costs and expected savings, concluded that the currently owned equipments aren't fit to be repurposed due to their age (over ten years) and outdated technology. Therefore, a new palletising and depalletising robot is the best choice in the market.

With the required investments and the processes' overall times, it was possible to assess when these different scenarios would reach a break even point.

For that purpose, the verification capacity and the estimated savings were calculated taking into account the number of trucks unloaded during 2014, their simultaneity and the number of shifts usually made. To ascertain these factors, the unloading plans from 2014 were processed using a developed Visual Basic for Applications macro in Microsoft® Excel®.

This macro's results were that 5 755 trucks were unloaded during 2014, where 2 719 of them happened during the same hour of the remaining 3 036, meaning that nearly 52.8% could have been verified with a process that would take up to one hour to complete. Although the estimated time to verify a full truck is lower than one hour, in any of the automatic scenarios, and higher than that in the manual verification setup, this was the percentage used to calculate the verification capacity and the expected savings. The main reasons for using this percentage were the non-existence of any other unloading plans with a higher resolution, and, using it, resulted in a worst-case analysis for the best scenarios and on a best-case analysis for the one with the lower results.

Table 6.1 presents the results of analysing all these three scenarios with all the information gathered and calculated to ascertain the break even point.

Table 6.1: Break even analysis of the different verification scenarios.

	Manual Verification (4 persons)	Automatic Verification (minimalist)	Automatic Verification (medium)
Investment	- 300 k€	- 550 k€	- 550 k€
Estimated Verification Time	1h 10m	35.5 min	40.5 min
Verification Capacity (16h)	40% (13.7 trucks)	78% (27.0 trucks)	69% (23.7 trucks)
Estimated Savings	+ 180 k€	+ 360 k€	+ 300 k€
Amortisation (8 years)	- 44 k€	- 69 k€	- 69 k€
Manual Labour	- 160 k€	- 40 k€	- 40 k€
Annual Result	- 24 k€	+ 251 k€	+ 191 k€
Break Even	**15.7 years**	**1.7 years**	**2.0 years**

With this analysis, it is concluded that either one of the automatic verification scenarios is profitable in a short-term and, therefore, should be implemented to the unloading phase of Unicer's reverse logistics processes.

It is important to note that the investment values presented on all these scenarios were assessed budgets provided by two of the industrial equipments manufacturers contacted (KHS and GEBO).

6.4 In Traffic - Radio Frequency Identification of Bottle Crates

One of the proposed improvements is to identify all bottles' crates with a RFID tag in order to identify the source of the bottles inside it, and impute the cost of the missing and foreign ones to who failed to deliver them. The RFID tag had to be embedded on the plastic crates and it would be read when picked up at the client and again at the unloading site. With an individual identification of the crates, the verification process can be applied to any arriving truck of refillables, independently of its composition, i.e., it wouldn't matter if the crates came from only one or several clients because their source can always be ascertained.

Additionally, the distributors, who may not be the ones failing to deliver the correct bottles, shall be interested in passing this cost to their own clients, instead of absorbing it themselves. Thus, they can be interested in sharing the required investment or join afterwards by paying a share of the investment made.

Furthermore, the accessibility of the radio-frequency technology provides Unicer with the opportunity to automate some of their processes that require the count and record of this vessels' stocks and movements.

An RFID tag's cost ranges from 0.10€ to 2.00€ according to their characteristics. In this case, there's no interest on using adhesive tags (the cheapest ones) since they can be easily removed and may even fall. So, the ones to be used in this case would be the ones of 2.00€ that have a plastic casing. The portable terminals and the fixed RFID reader for the verification process cost is, approximately, 2 500€ and 7 500€ respectively. The software licences for factories, distribution centres and warehouses costs 20 000€ per unit, and the ones for the portable devices range between 200€ and 500€ depending on the number of users.

The verification process could be done on the already existing crate classifier at the beginning of the returnable bottle's filling line, however, in this case, the time interval between having the assets retrieved and their verification is too high to consider this a feasible solution, since the deposit fees have to be returned in a period no greater than five working days.

Therefore, this proposed improvement suits Unicer's interests by extending the applicability of the previously presented one, on section 6.3, thanks to the possibility of verifying all trucks and not only the ones with a mono-client cargo composition.

Considering to apply this technology to the whole universe of returnable beer bottle crates used at the Leça do Balio centre, and that their number of market rotation cycles per year is between four and five, this improvement's implementation represents a total cost above 3 000 000€, mostly due to the RFID tag unit cost. Since the expected savings from mitigating the missing and undue bottles' cost, in this extension scenario, is of 51 066€ per year, it would take at least 60 years to get the return of investment (ROI), if Unicer invests on this technology only by itself. This is an absurd and undesirable period to wait at the present time, so, to implement such a technology on Unicer, either a better price per tag is negotiated or the quantity of crates to be tagged gets limited.

Restricting the universe of tagged crates to the ones that would benefit from being identified, means to identify a quantity equal to the ones returned within multi-client cargoes (10%). This way, the investment required would be between 300 000€ and 400 000€, and its ROI time would be between 6 to 8 years, which is way better than the one from identifying all crates but it is still too high to make this improvement proposal appealing.

Table 6.2 summarises the required investments for each scenario, making this information more comprehensive.

Table 6.2: Implementation costs of the different beer crates' RFID tagging scenarios.

		Crates' Percentage	
		100%	10%
Rotation	4	3 923 081 €	392 308 €
	5	3 138 465 €	313 846 €

6.5 In Traffic - Labelling of Returned Pallets

An alternative to identifying all crates is to identify the whole pallet at the unloading stage with a barcode, QR code, datamatrix or any other one or two-dimensional code.

A datamatrix label costs 1.50€ and two automatic reading equipments cost 30 000€, one for the unloading site and another one for the filling line. Thus, the cost of identifying all mono-client unloaded pallets of beer crates at the Leça do Balio production facility during 2014, would be of, approximately, 200 000€ based on the crates movements and the pallet's capacities.

This would allow to identify the crates being rated at the crate sorting station of the filling line. Thus, ascertaining the market return performance of 90% of the clients, the ones that fill a whole truck before having Unicer's assets retrieved.

Like the crate identification improvement, this one lacks the possibility of imputing the missing and undue bottles' cost to who failed to correctly deliver them because of the time interval between their retrieval and the verification process. However, this is the cheapest method to identify the prevaricators and provides Unicer with accurate and reliable information to undertake additional measures.

Chapter 7

Conclusion

7.1 Goals' Accomplishment

This thesis' goals were to analyse Unicer's returnable assets control processes, and to identify possible improvements and, according to the company's strategy, to implement some of them. One of the proposed improvements is already being implemented and another one is scheduled. The remaining improvements are waiting for the executive board's decision, due to their required investment and commercial impact.

Within this study, the good practices being made throughout other breweries in Europe (and Asia) were also evaluated, which helped to conclude that the best way to rectify the amount of glass bottles being retrieved is a verification process during the unload phase. Further more, this work will be a reference throughout Carlsberg's breweries, in order to analyse whether they should apply a verification method as well, or not.

All the stages taken to develop this study and reach its conclusions were described on this thesis and Unicer was very pleased with the performed work.

Considering all these results, it is concluded that this study's goals were accomplished.

7.2 Future Work

In the weeks following this thesis' writing, this study will be carried on until a decision is made to implement or not a verification method. If implemented, Unicer shall keep a continuous monitoring of the clients' return rates to measure the impact of having the undue and missing bottles charged back at them. The ideal scenario is one where they reach a return rate percentage so high that its costs are lower than the upkeep and maintenance of the implemented verification system. If it ever comes to that, this procedure shall be halted and the return rates verified at the filling line to determine the need to retake the verification processes or not.

In the future, it is recommended to use transparent crates to hold the returnable bottles, in order to allow for a simple and inexpensive verification methodology at the pick up points. It is also recommended to raise the clients' awareness, not only to the returnable glass bottles' value, but also to the non-returnable ones' ecological impact, to encourage the use of a more environment-friendly recipient, and lower the human footprint.

In a more futuristic scenario, the beer crates shall be highly technological with pressure or contact sensors only activated by selected bottles to automatically verify whether they are correctly returned or not.

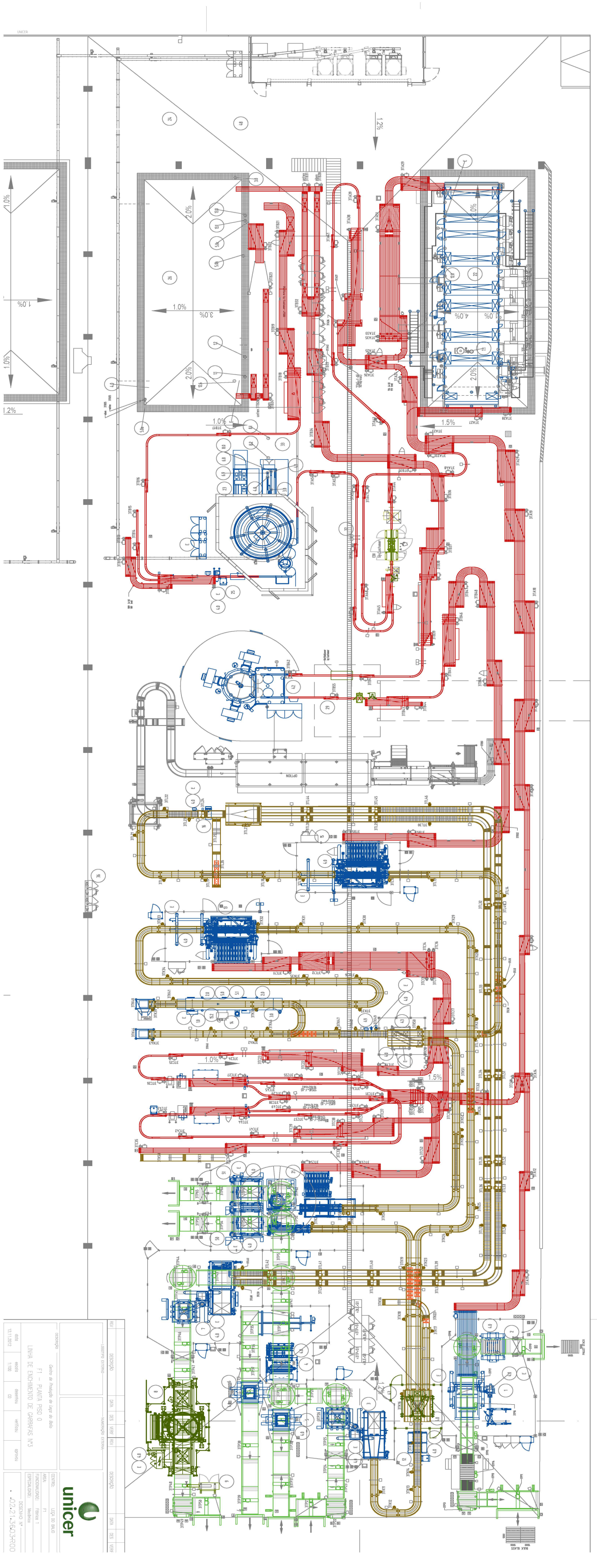
Appendix A

All Returnable Assets used by Unicer

SKU	Description	Deposit Fee (€)	Capacity
1001220	Garrafa Vidro Âmbar Cervejas 20cl TR C30	2.1	20 cl
1001225	Garrafa Vidro Carlsberg CLUB 25cl TR C30	2.1	25 cl
1001425	Garrafa Vidro Frisumo 25 cl TR	1.68	25 cl
1001525	Garrafa Vidro Pedras/Vidago 25 cl TR	2.16	25 cl
1002125	Garrafa Vidro Vitalis 25 cl TR	2.8	25 cl
1002425	Garrafa Vidro Verde Refrig. 25cl TR	1.68	25 cl
1002525	Garrafa Vidro P. Salgadas Source 25cl TR	2.16	25 cl
1001033	Garrafa Vidro Super Bock 33 cl TR	1.68	33 cl
1001133	Garrafa Vidro Âmbar Cervejas 33 cl TR	1.68	33 cl
1001950	Garrafa Vidro Vitalis 50 cl TR	2	50 cl
1001575	Garrafa Vidro Pedras Salgadas 75 cl TR	1.56	75 cl
1002575	Garrafa Vidro P. Salgadas Source 75cl TR	1.56	75 cl
1001901	Garrafa Vidro Vitalis 1 L TR	1.92	1 L
1008220	BARRIL REF 20 L	30	20 L
1008820	BARRIL VINHO 20 L	30	20 L
1007930	BARRIL S.BOCK 30 L	30	30 L
1008030	BARRIL CER 30 L	30	30 L
1058030	BARRIL CER 30 L EXPORT	30	30 L
1008130	BARRIL GUINNESS 30 L	30	30 L
1008330	BARRIL KRON. / GRIMB. 30 L	30	30 L
1007950	BARRIL S.BOCK 50 L	30	50 L
1008050	BARRIL CER 50 L	30	50 L
1005024	GRA TIPO C MÉDIA EURO	2	24 bottles
1005030	GRA TIPO C BAIXA EURO (C30)	2	30 bottles
1005230	GRA CARLSBERG (C30)	2	30 bottles
1005412	GRA TIPO C LITRO	2	12 bottles
1005524	GRA TIPO R BAIXA	2	24 bottles
1006112	GRA TIPO A LITRO (C12)	2	12 bottles
1006120	GRA TIPO A MEIO LITRO (C20)	2	20 bottles
1006128	GRA TIPO A MÉDIA (C28)	2	28 bottles
1006412	GRA TIPO A LITRO VMPS (C12)	2,3	12 bottles
1006424	GRA TIPO A MÉDIA CINZA VMPS (C24)	2,25	24 bottles
1008310	GARRAFA 10 KG	48	10 Kg
1008320	GARRAFA 20 KG	48	20 Kg
1008501	GARRAFA UNICER P/ N2CO2 1M3	48	1 m^3
1008810	GARRAFA 10 KG C	48	10 Kg
1008401	GARRAFA P/ N2CO2 1 M3	48	1 m^3

Appendix B

Layout Line #3



Appendix C

Returnable Assets Document Brought by Driver

unicer

Nota de Descarga

8676794470

Tipo: ZLRP-Return Dev. Prod/Vas **Cliente:** 200021-CERDISA-CENTRAL DIST.PROD.
ALI.,SA.
Data: 18.06.2015

[redacted]

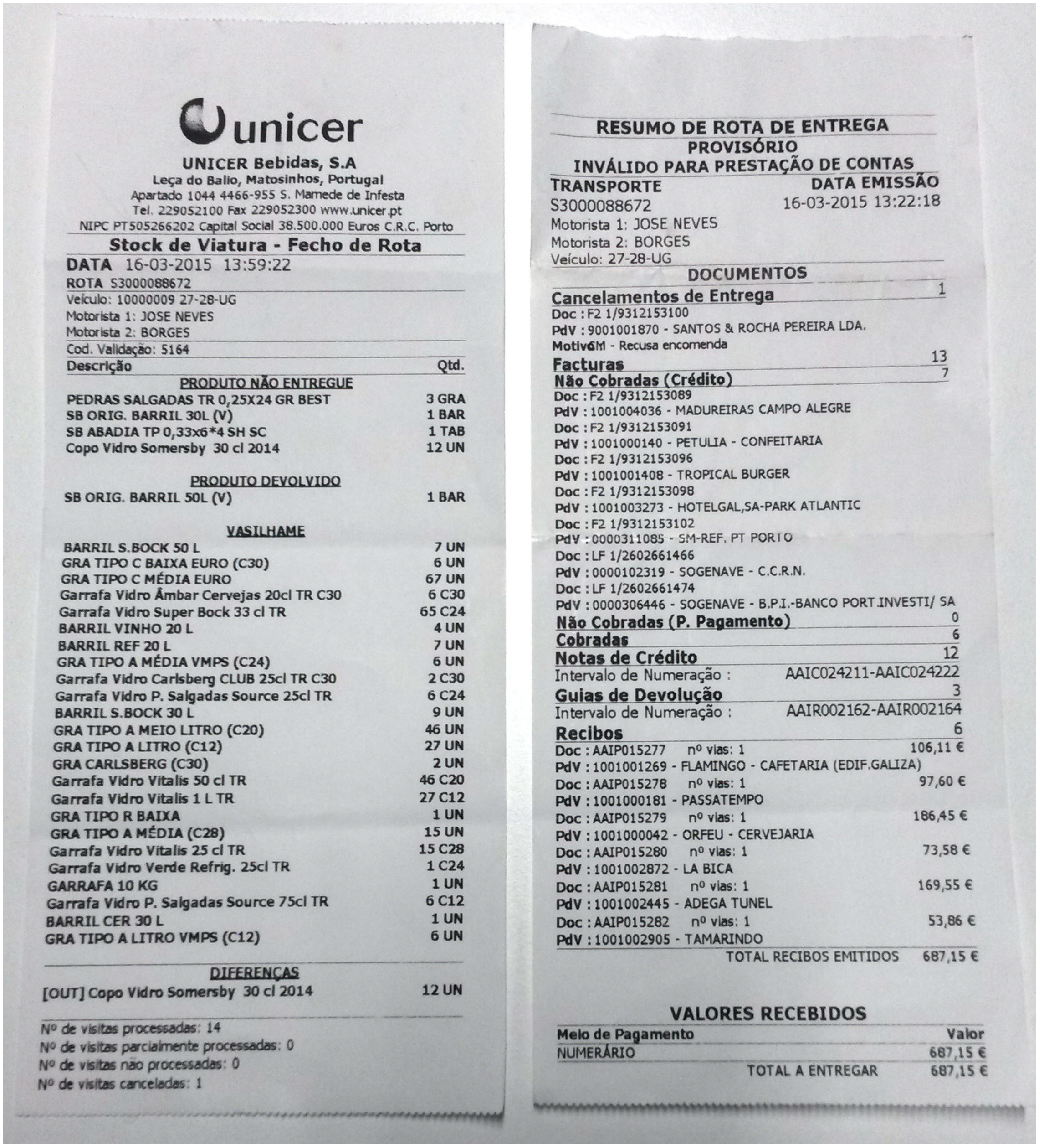
10	1009400	PALETE EUR LPR 1,20X0,80 M	32	UNP
20	1001133	Garrafa Vidro Âmbar Cervejas 33 cl TR	56,000	C24
30	1005124	GRA TIPO C MÉDIA	56,000	UN
40	1001033	Garrafa Vidro Super Bock 33 cl TR	1.288,000	C24
50	1005024	GRA TIPO C MÉDIA EURO	1.288,000	UN
60	1001220	Garrafa Vidro Âmbar Cervejas 20cl TR C30	256,000	C30
70	1005030	GRA TIPO C BAIXA EURO (C30)	256,000	UN
80	1001901	Garrafa Vidro Vitalis 1 L TR	128,000	C12
90	1006112	GRA TIPO A LITRO (C12)	128,000	UN

PROCESSADO POR COMPUTADOR

Página: 1 /
1

Appendix D

Returnable Assets Overview Receipts of Delivery and Retrieval Route



unicer

UNICER Bebidas, S.A
Leça do Balio, Matosinhos, Portugal
Apartado 1044 4466-955 S. Mamede de Infesta
Tel. 229052100 Fax 229052300 www.unicer.pt
NIPC PT505266202 Capital Social 38.500.000 Euros C.R.C. Porto

Stock de Viatura - Fecho de Rota

DATA 16-03-2015 13:59:22
ROTA S3000088672
Veículo: 10000009 27-28-UG
Motorista 1: JOSE NEVES
Motorista 2: BORGES
Cod. Validação: 5164

Descrição	Qtd.
PRODUTO NÃO ENTREGUE	
PEDRAS SALGADAS TR 0,25X24 GR BEST	3 GRA
SB ORIG. BARRIL 30L (V)	1 BAR
SB ABADIA TP 0,33x6*4 SH SC	1 TAB
Copo Vidro Somersby 30 cl 2014	12 UN
PRODUTO DEVOLVIDO	
SB ORIG. BARRIL 50L (V)	1 BAR
VASILHAME	
BARRIL S.BOCK 50 L	7 UN
GRA TIPO C BAIXA EURO (C30)	6 UN
GRA TIPO C MÉDIA EURO	67 UN
Garrafa Vidro Âmbar Cervejas 20cl TR C30	6 C30
Garrafa Vidro Super Bock 33 cl TR	65 C24
BARRIL VINHO 20 L	4 UN
BARRIL REF 20 L	7 UN
GRA TIPO A MÉDIA VMPS (C24)	6 UN
Garrafa Vidro Carlsberg CLUB 25cl TR C30	2 C30
Garrafa Vidro P. Salgadas Source 25cl TR	6 C24
BARRIL S.BOCK 30 L	9 UN
GRA TIPO A MEIO LITRO (C20)	46 UN
GRA TIPO A LITRO (C12)	27 UN
GRA CARLSBERG (C30)	2 UN
Garrafa Vidro Vitalis 50 cl TR	46 C20
Garrafa Vidro Vitalis 1 L TR	27 C12
GRA TIPO R BAIXA	1 UN
GRA TIPO A MÉDIA (C28)	15 UN
Garrafa Vidro Vitalis 25 cl TR	15 C28
Garrafa Vidro Verde Refrig. 25cl TR	1 C24
GARRAFA 10 KG	1 UN
Garrafa Vidro P. Salgadas Source 75cl TR	6 C12
BARRIL CER 30 L	1 UN
GRA TIPO A LITRO VMPS (C12)	6 UN
DIFERENÇAS	
[OUT] Copo Vidro Somersby 30 cl 2014	12 UN

Nº de visitas processadas: 14
Nº de visitas parcialmente processadas: 0
Nº de visitas não processadas: 0
Nº de visitas canceladas: 1

RESUMO DE ROTA DE ENTREGA
PROVISÓRIO
INVÁLIDO PARA PRESTAÇÃO DE CONTAS

TRANSPORTE S3000088672
DATA EMISSÃO 16-03-2015 13:22:18
Motorista 1: JOSE NEVES
Motorista 2: BORGES
Veículo: 27-28-UG

DOCUMENTOS

Cancelamentos de Entrega 1
Doc : F2 1/9312153100
PdV : 9001001870 - SANTOS & ROCHA PEREIRA LDA.
Motivo: SM - Recusa encomenda

Facturas 13
Não Cobradas (Crédito) 7
Doc : F2 1/9312153089
PdV : 1001004036 - MADUREIRAS CAMPO ALEGRE
Doc : F2 1/9312153091
PdV : 1001000140 - PETULIA - CONFEITARIA
Doc : F2 1/9312153096
PdV : 1001001408 - TROPICAL BURGER
Doc : F2 1/9312153098
PdV : 1001003273 - HOTELGAL,SA-PARK ATLANTIC
Doc : F2 1/9312153102
PdV : 0000311085 - SM-REF. PT PORTO
Doc : LF 1/2602661466
PdV : 0000102319 - SOGENAVE - C.C.R.N.
Doc : LF 1/2602661474
PdV : 0000306446 - SOGENAVE - B.P.I.-BANCO PORT.INVESTI/ SA
Não Cobradas (P. Pagamento) 0
Cobradas 6
Notas de Crédito 12
Intervalo de Numeração : AAIC024211-AAIC024222
Guias de Devolução 3
Intervalo de Numeração : AAIR002162-AAIR002164
Recibos 6
Doc : AAIP015277 nº vias: 1 106,11 €
PdV : 1001001269 - FLAMINGO - CAFETARIA (EDIF.GALIZA)
Doc : AAIP015278 nº vias: 1 97,60 €
PdV : 1001000181 - PASSATEMPO
Doc : AAIP015279 nº vias: 1 186,45 €
PdV : 1001000042 - ORFEU - CERVEJARIA
Doc : AAIP015280 nº vias: 1 73,58 €
PdV : 1001002872 - LA BICA
Doc : AAIP015281 nº vias: 1 169,55 €
PdV : 1001002445 - ADEGA TUNEL
Doc : AAIP015282 nº vias: 1 53,86 €
PdV : 1001002905 - TAMARINDO
TOTAL RECIBOS EMITIDOS 687,15 €

VALORES RECEBIDOS

Meio de Pagamento	Valor
NUMERÁRIO	687,15 €
TOTAL A ENTREGAR	687,15 €

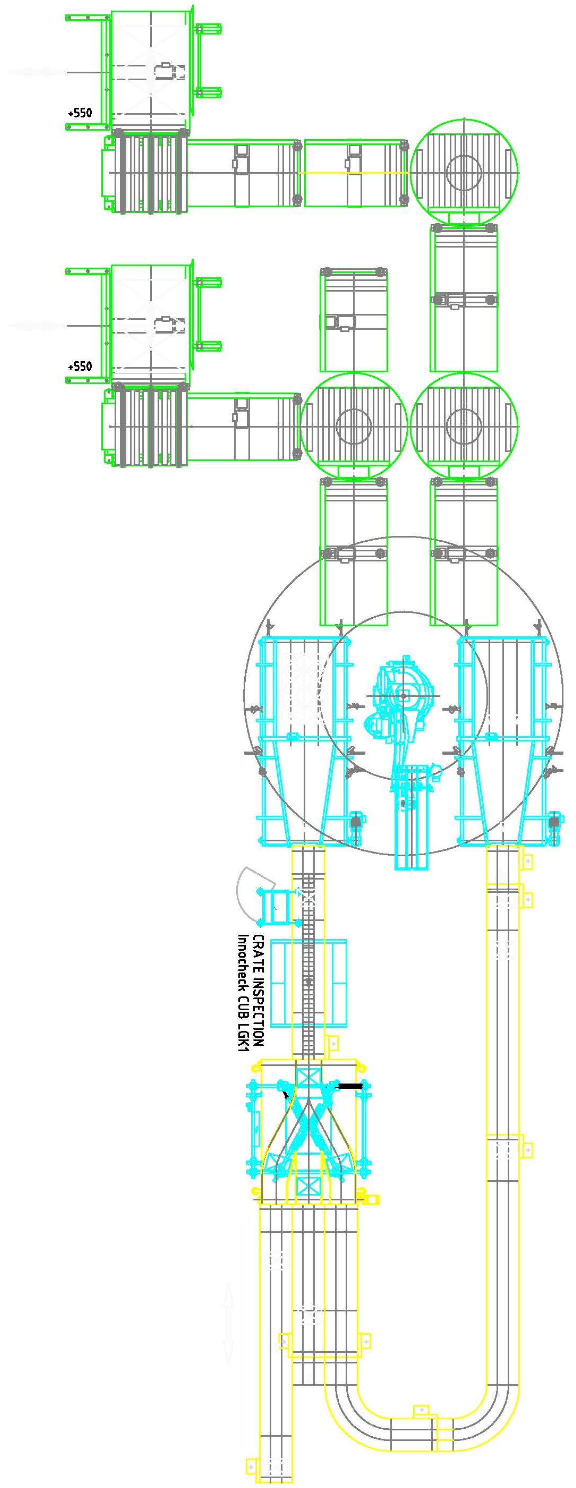
Appendix E

Vessel's Cockpit Interface


Sistema
Ajuda
Vasilhame - Cockpit
Ecran Completo
Carregar Var.
Eliminar Var.
Vasilhame
Critérios de Análise
Data 08.06.2015 até 14.06.2015
Organização vendas D001 até
Hierarq.produtos até
Material 1001033 até
Centro até
Grupo de clientes até
Emissor até
Pagador até
Agrupamento
Dia
Sem
Mês
Ano
Cent
Mat
Caucionamento
Apresentação
Todos
Errados
Corretos
Validação
Total
Quantidade
Valor
Execução
Versão 001
Executar
Data Centro EmissorOrd Nome Org.vendas CV Material Texto breve material Qtd Forn Real Qtd Forn P QtdFatU... V Cond Real V Cond P
12.06.2015 D023 600027 COMPRALBE D001 1005024 GRA TIPO C MÉDIA EURO 0,000 0,000 0,000 0,00 0,00
12.06.2015 D023 600027 COMPRALBE D001 1005030 GRA TIPO C BAIXA EURO (C30) 0,000 0,000 0,000 0,00 0,00
12.06.2015 D022 600027 COMPRALBE D001 1005030 GRA TIPO C BAIXA EURO (C30) 1.280,000 1.280,000 1.280,000 2.560,00 2.560,00
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1001033 Garrafa Vidro Super Bock 33 cl TR 336,000 336,000 336,000 564,48 564,48
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1001133 Garrafa Vidro Âmbar Cervejas 33 cl TR 48,000 48,000 48,000 80,64 80,64
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1001220 Garrafa Vidro Âmbar Cervejas 20cl TR C30 192,000 192,000 192,000 403,20 403,20
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1001225 Garrafa Vidro Carlsberg CLUB 25cl TR C30 56,000 56,000 56,000 117,60 117,60
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1005024 GRA TIPO C MÉDIA EURO 384,000 384,000 384,000 768,00 768,00
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1005030 GRA TIPO C BAIXA EURO (C30) 192,000 192,000 192,000 384,00 384,00
12.06.2015 D023 602092 MANUEL BARTOLOMEU ROMÃO HERDE... D001 1005230 GRA CARLSBERG (C30) 56,000 56,000 56,000 112,00 112,00
13.06.2015 D421 200727 EUROBEIRAS, LDA (COVILHÃ) D001 1001220 Garrafa Vidro Âmbar Cervejas 20cl TR C30 0,000 0,000 0,000 0,00 0,00
13.06.2015 D421 200727 EUROBEIRAS, LDA (COVILHÃ) D001 1005030 GRA TIPO C BAIXA EURO (C30) 0,000 0,000 0,000 0,00 0,00
228.368,000
434.360,30

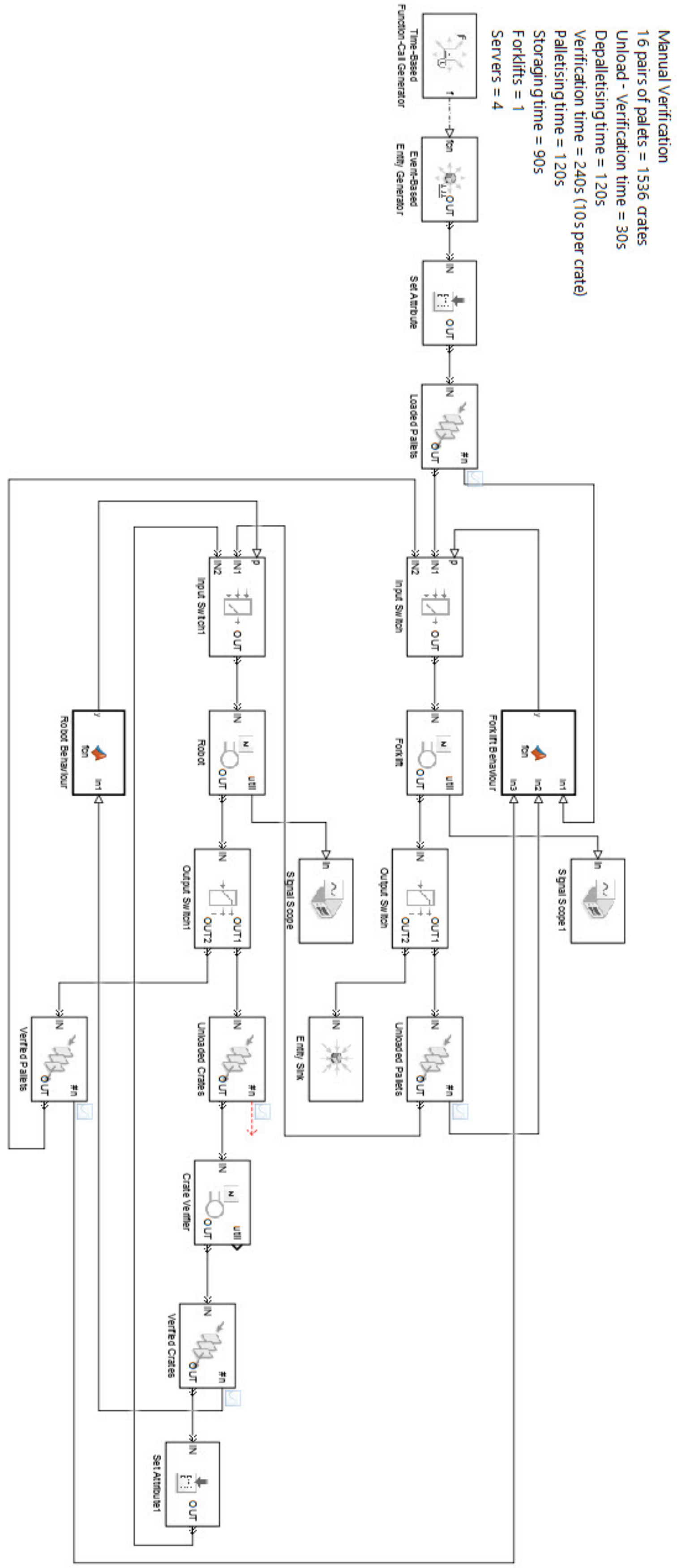
Appendix F

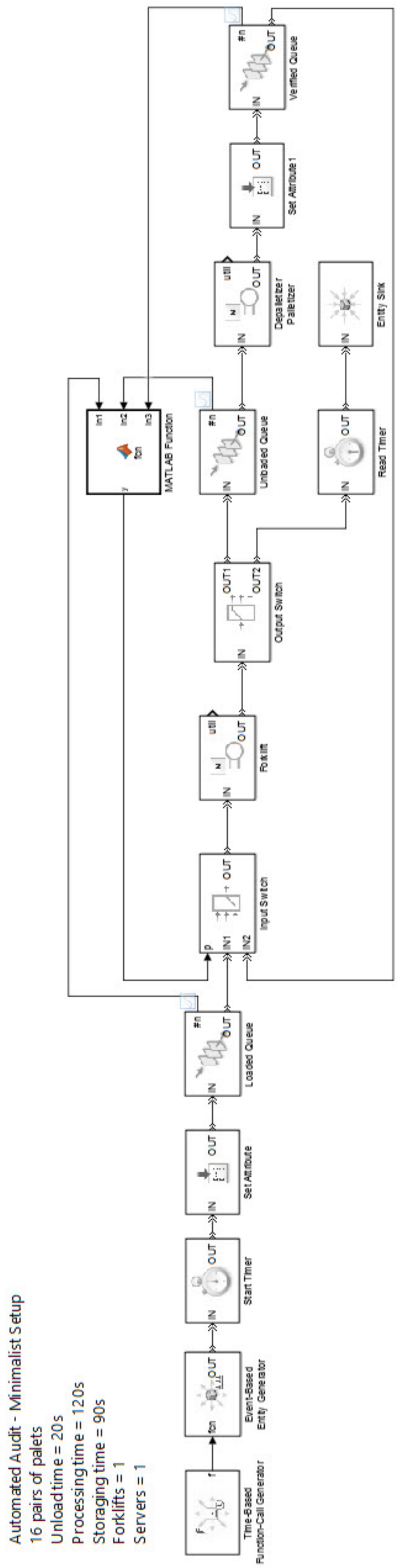
Automatic Verification Layout

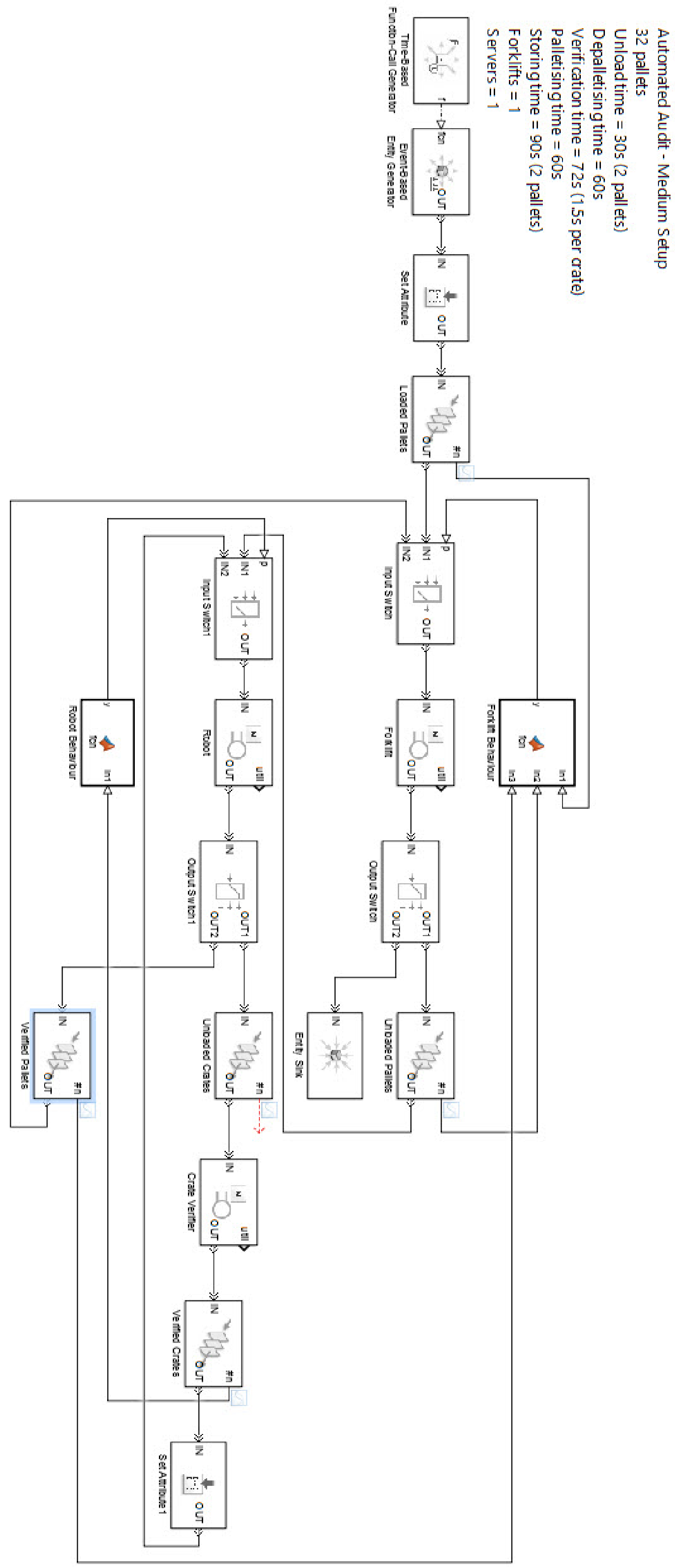

+550
+550
CRATE INSPECTION
Innocheck CUB LGK1

Appendix G

Automatic Verification Scenarios' Simulations Models


Manual Verification
16 pairs of palets = 1536 crates
Unload - Verification time = 30s
Depalletising time = 120s
Verification time = 240s (10s per crate)
Palletising time = 120s
Storaging time = 90s
Forklifts = 1
Servers = 4
Time-Based Function-Call Generator
Event-Based Entity Generator
Set Attribute
Loaded Pallets
Input Switch
Input Switch1
Forklift
Robot
Forklift Behaviour
Robot Behaviour
Output Switch
Output Switch1
Signal Scope
Signal Scope1
Unloaded Pallets
Entity Sink
Unloaded Crates
Verified Pallets
Crate Verifier
Verified Crates
Set Attribute1


Automated Audit - Minimalist Setup
16 pairs of palets
Unload time = 20s
Processing time = 120s
Storaging time = 90s
Forklifts = 1
Servers = 1
Time-Based Function-Call Generator
Event-Based Entity Generator
Start Timer
Set Attribute
Loaded Queue
Input Switch
Forklift
Output Switch
Unloaded Queue
MATLAB Function
Depalletizer Palletizer
Set Attribute1
Verified Queue
Read Timer
Entity Sink


Automated Audit - Medium Setup
32 pallets
Unload time = 30s (2 pallets)
Depalletising time = 60s
Verification time = 72s (1.5s per crate)
Palletising time = 60s
Storing time = 90s (2 pallets)
Forklifts = 1
Servers = 1
Time-Based Function-Call Generator
Event-Based Entity Generator
Set Attribute
Loaded Pallets
Input Switch
Forklift Behaviour
Forklift
Output Switch
Unloaded Pallets
Entity Sink
Input Switch1
Robot
Robot Behaviour
Output Switch1
Unloaded Crates
Verified Pallets
Crate Verifier
Verified Crates
Set Attribute1

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